

MALCOLM WATSON

STUDIES

FROM

INSTITUTE FOR MEDICAL RESEARCH,
FEDERATED MALAY STATES.

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Vol. 3.

Parts 1 & 2.

OBSERVATIONS ON
THE DISEASES
OF
BRITISH MALAYA.

BY

C. W. DANIELS, M.B. CAMB., M.R.C.S. ENG.

Director of the Institute for Medical Research, Federated Malay States.



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PREFACE.

The two previous volumes of Studies from the Institute of Medical Research were each on a special subject, Malaria and Beri-Beri respectively.

In this, the third volume, the plan of in each volume treating a separate subject has been abandoned, both because it has not been found practicable to so complete the study of any subject as to attain finality, and also because it has been necessary to make a partial study of so many subjects connected with the Public Health.

Many of these investigations are merely preliminary, but enough has been done to show that the local study of local conditions is a necessity for economically dealing with sanitary questions.

The application of general principles on lines advantageously adopted elsewhere requires for local needs much modification, and unless the knowledge is obtained of local conditions waste of money and inefficient sanitation will occur in the future as they have done in the past.

The present volume is divided into four numbers:—

No. 1 deals with observations made on the commoner diseases of men and animals.

No. 2. A preliminary report on the natural waters and the effects of methods for purification adopted.

No. 3 gives the results of an enquiry into the Culicidæ of Malaya.

No. 4 is an account of observations made on the epidemics of Rinderpest in Selangor in the last eighteen months, with an account of clinical characteristics of the disease.

An extra number on Beri-Beri will, it is hoped, be published later.

C. W. DANIELS,
Director, Institute for Medical Research, F.M.S.



PART I.

ПЯТА

Animal Parasites in Man and some of the Lower Animals in Malaya.

Many observations have been made on the presence of various animal parasites, but our knowledge of their occurrence in Malaya, of their life histories and of their effects on their hosts is still far from complete.

PROTOZOA.

Of the four great classes the Sacodina are represented by the *Amoeba Coli*. This *Amoeba* is common in some of the forms of dysentery, but is only occasionally met with in other forms. It has not been found by us except in association with ulceration of the colon or in the Intestine. It was found in all cases of Hepatic abscess examined. Attempts at cultivation either in artificial media, in flies and in larvæ failed.

INFUSORIA.

Paramoccium Coli and various other ciliated organisms were found in dysentery and occasionally in loose stools where there was no proof of ulceration.

MASTIGOPHORA.

In man were only represented by flagellate intestinal organisms, *Balantidium Coli*, in certain cases of dysentery. Trypanosomes in man were not found. In a horse Trypanosomes were found in large numbers and the animal died in a few days. Clinically all the symptoms of "Surra" were present. Guinea pigs injected with the fresh blood of this horse died in three months. Numerous trypanosomes were found in their blood. The animal had been in the States for two years and must therefore have become infected in the country. No previous case could be discovered, and it appears probable that a less susceptible animal than a horse had introduced the disease. In the course of numerous examinations of cattle, similar, though somewhat larger parasites were found in the blood of a buffalo (Siamese) recently imported. It is not improbable that as these animals are almost insusceptible to the effects of the parasites that the disease is occasionally imported in them from countries where "Surra" is endemic, and may in turn infect susceptible animals such as the horse in this instance. No *Glossina* are known here, but there are numerous species of biting flies.

It is difficult to see how such an importation could be prevented.

SPOROZOA.

This class is well represented, and the members of it are the causes of numerous diseases both in man and in the lower animals.

Malarial Parasites are widely but not uniformly distributed. The distribution of the different species as seen in the District Hospital in Kwala Lumpur are shown by Dr. McClosky to be as follows :—

MALARIA AT THE DISTRICT HOSPITAL, KWALA LUMPUR, DURING 1903,

BY A. J. McCLOSKEY, M.B., C.M., EDIN.

1. Microscopical examination of the blood of all cases of Malaria was made at the Institute for Medical Research, and a diagnosis made according to the parasites found.

2. Two hundred and fifty-three cases were treated during the year, classified according to the following types: Malignant, Quartan, Benign Tertian and mixed types.

The following table shows the number and percentage of each type and compared with the preceding year :—

TYPES.	1903.		1902.	
	Number.	Percentage.	Number.	Percentage.
Malignant	136	53.73	77	43.57
Quartan	79	31.22	55	30.72
B. Tertian	26	10.27	41	22.9
Malignant and B. Tertian ...	10	3.95	3	1.14
„ „ Quartan	1	.39	1	.55
B. Tertian and Quartan	1	.39	2	1.11
TOTAL ...	253		179	

There has been a marked increase of Malaria this year as compared with the previous year. This increase is mainly due to the large number of admissions from amongst the coolies working at Ulu Gombak. The order of prevalence of the different types of fever is the same for both years, and does not correspond with that given by Dr. HAMILTON WRIGHT in his Study No. 1, in which the Benign Tertian is shown to be more prevalent than the Quartan Type.

3. The districts from which most of the cases came are as follows:—

			Quartan.	B. Tertian.	Malignant Tertian.	Per cent.		
						4 Quartan.	3 Tertian.	1 Mal. Tert.
Kwala Lumpur ...	66	20	13	33	30.3	19.0	50	
Gombak ...	45	12	3	30	26.6	6.6	66.6	
Ampang ...	28	9	1	18	32	3	64	
Kepong ...	12	5	1	6				
Panthal ...	10	1	2	7				
Pudoh ...	8	2	—	6				
Ulu Klang ...	7	1	1	5				
Sungei Besi ...	7	3	—	4				
Simpang ...	7	1	2	4				
Setapah ...	6	1	—	5				
Kajang ...	9	6	1	2				
Total ...	...	...	...	...	29.7	11.7	58.5	

The particular streets in Kwala Lumpur from which the patients came could not be ascertained in all cases, but those obtainable were as follows:—

Batu Road, 18; Java Street, 11; Brickfields, 8; High Street, 3.

The following table shows the monthly admissions and rainfall:—

1903.				1902.	
MONTHS.		ADMISSIONS.	RAINFALL.	ADMISSIONS.	RAINFALL.
January ...	...	17	4.99	17	2.76
February ...	...	15	3.68	6	9.43
March ...	...	19	9.19	7	6.91
April ...	...	28	7.03	13	13.71
May ...	...	20	13.81	10	9.99
June ...	...	25	4.40	12	6.99
July ...	...	21	1.97	14	3.19
August ...	...	12	6.70	17	7.46
September ...	...	22	4.51	22	5.48
October ...	...	18	11.58	17	18.18
November ...	...	19	8.82	11	19.48
December ...	...	25	12.55	10	11.80
TOTAL ...	...	241	89.23	166	115.38

The only deduction which can be drawn from the above table is that in each year the month in which the rainfall was lowest, viz., July and January respectively, was followed by the month in which the admission rate was lowest.

The following table shows that in the past two years there has been no great seasonal variation in the prevalence of the parasites:—

MONTHS.														
	Malignant.	Quartan.	B. Tertian.	Malignant and B. Tertian.	Malignant and Quartan.	Quartan and B. Tertian.	TOTAL.	Malignant.	Quartan.	B. Tertian.	Malignant and B. Tertian.	Malignant and Quartan.	Quartan and B. Tertian.	TOTAL.
January ..	6	7	4	..	..	..	17	4	8	5	..	..	..	17
February ..	5	6	4	..	..	..	15	8	4	4	..	..	..	16
March ..	8	8	3	..	..	..	19	3	1	2	..	..	1	7
April ..	11	11	2	3	..	..	28	7	4	3	..	..	..	14
May ..	7	7	1	3	..	1	20	3	4	2	..	..	1	10
June ..	14	10	1	..	..	..	25	7	2	2	1	..	..	12
July ..	15	3	1	1	1	..	21	2	..	12	..	..	..	14
August ..	10	1	1	..	..	..	12	12	4	1	..	..	..	17
September ..	14	5	1	2	..	..	22	15	5	..	1	1	..	22
October ..	15	2	1	..	..	..	18	8	7	2	..	..	..	17
November ..	12	6	1	..	..	..	19	2	3	5	1	..	..	11
December ..	18	4	2	1	..	..	25	1	9	..	..	..	..	10

Admissions of the Malignant type were more numerous during the last six months of the year, as the following figures show:—

	1903.	1902.
1st six months	51	33
2nd „	84	43

Malignant Parasite.—This is the most common parasite met with at the District Hospital. Doubly infected corpuscles were frequently met with, and I have seen as many as five parasites in one corpuscle. Examination of fresh blood films showed (1) young active amœboid forms; (2) quiescent ringlets with and without pigment, pigment generally active, as fine granules or rods; (3) brassy bodies; (4) crescents and globular bodies of the crescent series.

Quartan Parasite.—Single infections are more common than in the Malignant and B. Tertian fevers. Fifty-three per cent. of the cases were single infections. Out of 41 cases, 22 were single infections, 11 double and 8 triple. Examination of fresh blood films showed (1) young active amœboid forms; (2) pigmented parasites, pigment sluggish and in form of fine rods; (3) corpuscles not enlarged and not changed in colour; (4) sporulating bodies.

Benign Tertian Parasites.—Double infection is common. Out of 21 cases, 14 were double and 7 single infections.

Examination of fresh blood films showed (1) young active amœboid forms; (2) pigmented parasites, pigment very active and in form of fine granules; (3) hosts enlarged and pale; (4) sporulating bodies; (5) extra corpuscular forms; (6) small free pigmented bodies with the pigment very active.

It may be noted that the prevalence of Quartan shown in Dr. McClosky's report is not universal throughout the Federated Malay States. It is rare in Kwala Lumpur amongst Europeans and amongst the better class natives who are admitted to the General Hospital. Out of 255 cases in which the blood was examined the proportions were Quartan, 2 per cent.; Tertian, 40 per cent.; and Malignant Tertian, 58 per cent. It is rare in other districts such as Klang.

Dr. H. WRIGHT (The Malarial Fevers of British Malaya Studies from the Institute for Medical Research, No. 1, Vol. 1) gives out of 251 cases percentages of 22.3 per cent. Quartan, 31 per cent. Benign Tertian, and 46.2 per cent. of other types.

Of the cases of Malaria treated at the District Hospital only 28.8 per cent. were from Kwala Lumpur. Of the remainder 45 or 23 per cent. of the total were from Gombak, a district where extensive works in partially cleared jungle are being carried out. Under such circumstances in Malaya Malaria is as severe and prevalent as in bad parts of Africa.

The variation in the distribution of anopheles is dealt with fully elsewhere.

CONDITIONS FAVOURING PREVALENCE OF MALARIA.

The conditions under which Malarial Fever becomes epidemic in Malaya vary. In large towns it occurs but only as isolated cases or small groups of cases.

The more important places are:—

- (1) Where extensive works are undertaken in jungle.
- (2) In the low lands at the mouths of rivers and near the sea.

Of the first class the works in connection with the Electric Power Station at Gombak may be taken as an example. This place is of particular interest as it is one of those reported to be free from mosquitoes. It is so to the extent that mosquitoes are not troublesome, are rarely found in the houses, and that mosquito curtains are unnecessary for comfort only. Examination of breeding places shows that mosquitoes are widely distributed, and in particular that an anopheles, *Anopheles Treacherii* is to be found in every stream, and that other anopheles *Myzomyia leucophyrus*, *Lophoscelomyia asiaticas*, etc., are also to be met with in places. *Anopheles Treacherii* dies rapidly in dry air and is only found in streams in jungle. These streams are often rapid, and in hilly and rainy districts, such as Gombak, vary in size from mountain torrents to a mere trickle in the space of a few hours.

The huts—bangsals—were situated at the edge of the clearing in the jungle and close to one or more of these streams. In most cases the clearings were very small and incomplete.

In these huts men from all parts of China, India or the Malay Peninsula, slept crowded together without any protection against mosquitoes.

Our statistics here show that adult Chinese are not immune to any form of Malaria any more than adult Europeans, Asiatics, Americans or Africans are unless reared and living in a badly malarious district.

Most of the men are Chinese highly susceptible to Malaria, and amongst them will always be some who are harbouring malarial parasites. From these the mosquitoes, which are not numerous, become infected and in turn infect every susceptible person they bite. So great is the liability to infection that in three instances to my own knowledge a single night's residence was followed in 10 days by an attack of Malaria. Children play no part in the propagation of Malaria, it is entirely a question of infected adults infecting, *via* mosquitoes, other susceptible adults, as there are no children at such camps.

It will be noted that no question of drainage, filling up of pits, etc., can arise in connection with these mountain streams. Something might be done at considerable expense by clearing the course of the streams, but as these streams are running over masses of granite or between granite boulders it could not be economically undertaken for temporary stations.

In some instances artificial obstructions to the streams are made in the course of felling the jungle, and portions of the streams in the vicinity of the huts are often dammed up for bathing and other purposes. Such practices should be avoided.

Mosquito curtains in a place where mosquitoes are not troublesome are not satisfactory, as it is impossible to enforce their use on persons who are engaged for short periods only. *A. Treacherii* is a very small mosquito, and when confined in mosquito nets sometimes passes through.

Advantage should be taken of the inability of the imago to live in dry air. More extensive clearings on all sides of the huts and drier houses will render the human habitations unsuitable for these mosquitoes.

Such measures were partially undertaken at Gombak and for some months the amount of Malaria was much reduced. As the growth of the imperfectly cleared land recurred the returns were nearly as bad as at first.

Work under similar conditions has been attended with very heavy mortality and much Malaria in many parts of the Malay States. It will continue to do so till good clearings are made and maintained for the labour employed on such works.

The contract for such clearings and camps and the labour employed on the clearings and other sanitary work should be distinct from the contracts and bodies of men employed on the works themselves. Experience has shown that with the desire to expedite works all available labour if under one authority is diverted to that work and sanitary undertakings are neglected.

The second class of place of great importance is that occurring on extensive flat swampy areas near the coast or towards the mouths of rivers.

Here the conditions as regards housing of labour may or may not be similar to the temporary camps established in the jungle. In any case conditions for introduction and spread of Malaria are present, and susceptible individuals abound.

The level of the subsoil water is high, pools are formed with each shower and many of them are permanent. In any engineering undertaking it is common to find that roads, railway permanent way or embankments are made without due regard to the necessity of maintaining the natural system of drainage or of providing a superior one. In the making of these embankments "borrow pits" are made in numbers and no provision made for their drainage.

Under these circumstances mosquitoes of many genera abound, and amongst these are several species of anopheles though not the species prevalent in the jungle.

Drainage of such areas presents no real difficulty, and where a permanent station is to be formed is economical as well as successful.

This is well illustrated by the success which has attended this method of dealing with the matter at Klang and Port Swettenham.

Two areas were treated. One consisted of swampy ground near the coast through which the Klang River passed. This region is partially closed in by a semicircle of hills. The second was flat land and mangrove swamp on the coast flooded at high tides.

During clearing of the mangrove there was a certain amount of Malaria amongst those employed.

When a railway embankment was built there was great interference with the natural drainage and the swampy areas were increased, rendered more permanent, and protected to some extent from flooding by sea water.

A great increase in the number of cases of Malaria occurred so much as that between September 15th and November 25th, 1901, out of 260 inhabitants of certain quarters and shop houses 158 or 60 per cent. were attacked. In the township of Klang, some $2\frac{1}{2}$ miles up the river at the foot of the hills and very swampy, Malaria was also rife.

A Government Commission composed of three engineers and three medical men was appointed, and as a result of their enquiries extensive carefully devised measures were undertaken at a cost of some £3,500. The results were highly satisfactory. In the last quarter of 1901 the admissions for malaria for the two townships were 252; for the same period in 1902 they were only 26. Full details are given in the reports by Drs. TRAVERS and WATSON.

These satisfactory results were obtained although the drainage was not complete, and there is no difficulty in still finding places, especially during wet months, in which anopheles larvæ can still be found. Dr. LEICESTER has shown that the species of *Anophelina* in the drained area does not correspond to those met with in the undrained, and that the great majority of larvæ found in the districts treated are now the comparatively harmless *M. Rossii*, whilst other species not found in these areas abound in the surrounding untreated district.

The effect of the drainage has not only been to diminish the number of breeding places, but also to exclude certain species. The measures adopted have reduced the amount of Malaria and the deaths from Malaria in hospital from 52 in 1901 to 9 in 1902, and still more the general death rate, whilst there has been no reduction in these rates in the surrounding district.

This has been accomplished by the adoption of measures which aimed at reduction and not at abolition of breeding-places in the respective areas. A certain amount of up-keep is required, and it is to be anticipated that

further measures which can gradually be adopted will still further reduce the amount of sickness.

An exact knowledge of breeding-places of mosquitoes in Malaya shows that in such situations partial measures are successful, as under such conditions only poor carriers of Malaria abound, as *Myzomyia Rossii*. Under similar conditions in Africa more complete measures would be required as *Pyretophorus costalis*, a good carrier of Malaria, which is not found here would thrive.

In spite of this object lesson and the publicity given by the Government to the results obtained, it is noteworthy that similar insanitary conditions to those made at Klang and Port Swettenham are still being artificially produced in many parts of the country. Undrained "borrow pits," holes for brickmaking in the vicinity of houses, drains, embankments and roads which interfere with drainage are not only left unaltered but the number of them is daily being added to.

It should be a matter of no surprise to find that the first result of "opening up of new ground" is a large increase in the amount of Malaria, and the more these undertakings are in charge of Europeans—the more thoroughly the work is done—the greater the probability of this increased unhealthiness.

Another method by which the number of breeding-places is artificially increased is that in which a water course is dammed up in order to divert a stream for mining, irrigation or other purposes. Such a dam necessarily causes a backing up of the water behind it, a rise in level of the subsoil water and frequently flooding of low lying lands in the neighbourhood of streams. A good example of these conditions is to be seen at Seremban, and from near areas so flooded even in dry weather, most of the cases of Malaria, according to Dr. MILNE, are derived.

CONTRAST WITH CONDITIONS ELSEWHERE.

A contrast with the conditions in Central and East Africa and those in Malaya is of interest. None of the anopheles in the one country are found in the other. The most dangerous African anopheles, *Myzomyia funesta*, is a stream breeder, but it breeds freely in streams and rivers passing through open country, and can travel freely in a dry atmosphere for certainly several hundred yards. No clearing of jungle or building of dry houses is of any avail against this mosquito, and the numbers can only be reduced by clearing the beds and banks of streams. Beyond this reliance has to be placed on the use of mosquito nets and quinine.

The other African mosquito of most importance is *Pyretophorus costalis*, which, though it is found in pools and streams, seems to be most abundant in any stagnant water and particularly in shallow rock or other pools near human settlements. It breeds under much the same conditions as the harmless *Myzomyia Rossii* in Malaya. These correspond to our coast conditions, and where effective drainage can be undertaken and maintained this is the successful economical and permanent settlement of the question.

In Southern Europe the important carrier is *A. maculipennis*, and this mosquito breeds under varied conditions including those suitable in this country for *M. Rossii*.

In Malaya fortunately simpler and less complete measures are required than in Africa or in Europe, on account of the different species which are dangerous in the three continents. The prevention and diminution of Malaria is therefore comparatively easy.

FATAL MALARIA.

In a considerable number of cases at the autopsy there was evidence of old or recent Malaria in the shape of pigmentation of the spleen or liver.

In those in which only a few parasites were present Malaria, though possibly a contributory cause of death, could not be considered as the main cause. In some of these, as in one case of Quartan Malaria, Beri-Beri was detected during convalescence from the attack of fever. There was no recurrence of the fever and no parasites, but abundant malarial pigment was found at the autopsy and the patient died of Beri-Beri.

In two of the cases in which death was attributed directly to Malaria there was some tubercular disease of the lungs. In the one case as an old wrinkled sclerotic mass surrounding some cretaceous nodules at one apex, and in the other recent tubercular infiltration affecting only a small part of the apex of one lung.

In three cases Dysentery and Malaria co-existed, and as clinically the dysenteric symptoms masked those of Malaria these cases in which death was probably the result of the combination are excluded from the table as well as one case of advanced anæmia with sloughing cellulitis of the leg. Of the remaining 15 cases in all parasites were found in large numbers in cerebral and other capillaries, and they are considered as fatal cases of Acute Malaria.

The parasites found in all were the so-called Autumnæstival or Malignant Tertian parasites.

The ages of the patients when ascertained were as follows:—Two, 25 and under; four, 30 and under; two, 35 and under; two, 40; and two over 40; a difference from the proportions dying at various ages in this hospital in that twice as many were in the most active life periods under 35 as over it, whilst the ordinary proportion amongst the fatal cases of disease was equal under and over.

Fatal cases occurred amongst patients from Kwala Lumpur from the mining districts and particularly from Gombak, where extensive engineering works are being undertaken.

Four died within a few hours of admission, and five more within three days. Four lived a week and over a week. Of those not dying within the first day Quinine in 10 gr. doses was given two or three times a day in several cases, and in some of these the temperature became normal, and remained so in one case for three days before death. Though the symptoms were thus reduced the large number of active and sporulating parasites found in the capillaries showed that the treatment had not been effective in the sense of destroying or preventing the development or reproduction of the parasites in these cases. In other cases the rapid and complete recovery and the prolonged disappearance of parasites of the same type from the blood under the same treatment shows that such treatment may be and often is effective.

This variation in the effect of small or medium doses of Quinine though well known is not easily explained in the ordinary theory of mere poisonous

action of Quinine dissolved in the blood serum on the parasites. The result of giving large doses where small doses fail and even increasing both the frequency and the amount of the doses in severe cases almost to an unlimited extent is usually found to be highly satisfactory. In two of the fatal cases intramuscular injections of 5 grains were given every two in one case and every 3 hours in the other on the day on which death occurred.

Coma was not present in all the fatal cases; death in several seemed to be the result of collapse or slow cardiac failure.

Intense congestion of the alimentary tract was present in three cases and in one other, though neither ulceration nor marked congestion was found at the autopsy blood had been passed per rectum in quantities two days before death. The frequency of Epistaxis in Malaria is well known.

The two organs most commonly enlarged in Malaria are the liver and spleen. In these cases the average weight of the spleen was 476 grams., in two cases it was under 300 grams., and in three under 400; in two it was over 700, in one over 600, and in four over 500. As the normal weight varies from 150 to 250 grams., it will be seen that the enlargement was slight in two and moderate in three more and in none extreme.

As compared with the cases of Enteric occurring in the same race, Chinese, there is little difference, as in these the average weight was 380, one of the spleens being only 190 grams. The others were respectively 270, 435 and 635 grams.

In the malaria cases the average weight of the liver was 1,568 grams., or little above the average normal weight, and in only four was it over 1,800 grams., two were under 1,200 grams.

The enlargement of the liver is far less marked than in Pneumonia, but slightly more than in the Enteric cases here, as these had an average weight of 1,505 grams.

There were no cases of Hæmoglobinuric (Blackwater) Fever, even from the intensely malarial Gombak district. At Klang, near the coast, one case was reported by Dr. WATSON. The course of the disease and the character of the urine were similar to those in a mild attack of Blackwater Fever in Africa.

The so-called Leishman Donovan bodies were not observed. No cases clinically resembling the disease associated with these parasites were seen by me.

I am informed that amongst Tamil immigrants cases do occur with the association of enlarged liver and spleen and irregular pyrexia unaffected by Quinine. These have not been seen by me or examined for these bodies.

PIROPLASMOSIS.

The most important of the sporozoa affecting the lower animals here is the *Piroplasma Bigeminum*. In 4 out of 13 Siamese cattle convalescent from Rinderpest these were found, but in very small numbers.

Subsequently Dr. LEICESTER made a larger series of examinations and found as follows:—

Dr. LEICESTER'S EXAMINATIONS.

1st Series.—12 Siamese bullocks.—11 had Rinderpest, and in 9 Piro-soma were found, including one which recovered. One was never ill and no piro-soma were found.

2nd Series.—15 bullocks.—1 Siamese, 3 cross between Siamese and Indian, 10 Indian and 1 calf. Of the Indian 7 had Rinderpest and 5 recovered. Piro-soma were found in all. There did not have Rinderpest, and 2 of these had Piro-soma. The calf also had Piro-soma. Of the three half breeds all had Piro-soma.

This gives a total of 27 cattle of mixed breeds with 23 infections, or 85.1 per cent. When it is remembered that many of the infections were so small that prolonged search was required to find a single parasite this percentage is probably below the real number indicating the proportion of infected animals, and indicates that practically all cattle here are infected with the parasites.

The state of affairs appears to be very similar to that found by KOCH in East Africa. There is a general infection of the cattle. The animals in their normal condition harbour the parasites only in small numbers and are insusceptible to the effects. When much reduced as by an attack of Rinderpest the parasites increase, and this secondary infection or rather exacerbation occurs and appears to be a cause of part of the mortality from Rinderpest. The animals die in reality from the combination of the two diseases.

A still more important point is the liability to severe infection of cattle imported from many parts of Australia. These imported cattle are known to be highly susceptible to the disease.

In one of these imported animals a severe attack of typical "redwater" or "Texas" fever was observed, and Piro-soma were found in the blood. It is a common experience that such imported cattle frequently die within a few months after arrival in the country.

The matter is a serious one as it will be difficult to improve the breed of cattle here unless care is taken to import cattle only from places where the disease is endemic and the animals have acquired immunity.

Other imported cattle should not be allowed to graze on land that has been grazed on by the native, Siamese or Indian, cattle, as the ticks, the definitive hosts, of the disease abound and many must be infected. The ticks found on cattle appear to be the Australian Species *Boophilus Australis* and not the *Boophilus Bovis* which carries the disease in America and Europe.

The precautions required are so elaborate and would be so difficult to carry out that the importation of such animals should be avoided.

OTHER PROTOZOA.

Hæmosporozoa were found in several species of monkeys. They resemble the subtertian parasite of man but the gamete forms are spherical. In a flying fox Dr. FINLAYSON found parasites which closely resemble those found by DRONISI in bats in Italy. They resemble the gamete forms of human Quartan Malaria. Halteridium occurs in several species of birds. Proteosoma were not found in the sparrows. Probably this is related to the scarcity of *Culex Fatigans* except in the vicinity of the more permanent settlements.

One case of Relapsing Fever was observed by Dr. FLETCHER. *Spirilla Obermeieri* were found in large numbers. The patient was from Northern India and had only been a few days in the country so that he brought the disease with him. He had a single attack and no relapse. The disease has not spread.

In frogs of several species and in a crocodile *Drepanidia* were found. Those in the crocodile were peculiar on account of the extensive vacuolation. No extra corpuscular forms were observed. They displaced the nucleus of the red corpuscles in a manner similar to that of one species found in frogs, but otherwise have no close resemblance to those parasites.

Coccidium Oviporme is found in the majority of rabbits either imported or bred in the country.

Sarcosporidia in large numbers were found in the cardiac muscle of an imported Australian bull which died some three months after arrival in the country. At first the animal appeared to be in good health but then commenced to get "fever." Texas fever was suspected, but though numerous examinations were made the piroplasm was never found. Irregular though less severe fever continued for nearly up to the time of death, and the animal steadily lost weight and condition. The immediate cause of death was intercurrent disease Acute Pleuropneumonia and Pericarditis.

HELMINTHS.

The number of intestinal and other worms met with in lower animals in the Malay Peninsula was very large. As none of these seem to attack man or the domesticated animals, only those found in man and domesticated animals are, with a few exceptions, here considered.

As regards the presence of these parasites in man it must be borne in mind that they are not necessarily indigenous, as the greater number of the examinations were made on Chinese or other imported races of mankind, and that the greater number of domesticated animals are also imported. As, however, these parasites, even if introduced originally, may become widely diffused, the importance of their occurrence is or may be great.

Platyhelminths.—In man the Trematodes are represented by *Distoma Sinense*, *Opisthorcis Sinensis*, which has been found on several occasions, five out of 328, in the gall bladder or bile ducts of Chinese residents. Though the bile ducts are often much distended these parasites do not cause symptoms of obstruction or apparently produce any serious disease. Ova of these worms have been sent from other parts of the States so that it appears to be widely diffused amongst the Chinese now resident here. In the lower animals Trematodes are more common.

Mr. FORD, Government Veterinary Surgeon, has observed in Bullocks and Buffaloes *Amphistoma conicum* at almost every examination of the rumen of these animals. In one bullock unusually large, 35 mm., specimens of the *Distoma Hepaticum* readily recognised by the cuticular prickles were found in the liver. From another bullock he forwarded to me a specimen of the spleen with the venous cavities dilated with innumerable specimens of *Bilharzia Crassum* (*Schistostoma Crassum*). There is no reason to believe that this parasite is common. The human species of the *Schistostoma* appears to be unknown here. No other organs were forwarded for examination, but as the spleen is an uncommon place for the accumulation of this

parasite it probably also occurred in numbers elsewhere. The new *Schistostoma*, *Schistostoma Cattoi* (Blanchard) discovered in the body of a Chinaman in Singapore has not been found here.

CESTODES.

No tape-worms were found at any post-mortem examination or observed during life. This is somewhat remarkable considering the fondness of the Chinese for pork. The care exercised by the Chinese in the feeding of pigs is probably their safeguard.

In one buffalo calf observed by Mr. FORD segments of a large tape-worm, probably *Tænia Expansa*, were passed.

In dogs, *Tænia Cucumerina* (*Dipylidium Caninum*) is common. One incomplete specimen of a *Bothriocephalus* was received by me from Mr. FORD. The segments were nearly mature and crowded with ova. There was no head. The yellow colour and the size, 4 to 5 mm. in breadth and 1 to 1.5 mm. in length, is compatible with the Canine *Bothriocephalus fuscus*. The ova were 50 u. by 32 u. in breadth. The specimen was not of *Bothriocephalus latus*. I am informed that dogs are often fed on fish.

No Echinococci have been found in the dogs here. The sheep frequently harbour Echinococci cysts, but as the sheep are imported and carefully kept there is little danger of the spread of this pest.

One case of Hydatid Cyst was found at a post-mortem examination of a Chinaman. It was probably imported though the man had been some years in the country.

Rats in Singapore as shown by Dr. FINLAYSON are often infested with cystic tumours of the liver containing immature tape-worms. These cystic tænia differ from echinococcus in the enormous development of the neck, which in some instances was 60 mm. in length. Probably these worms are *Cysticercus Fasciolata* cystic or embryonic stage of tænia crassicollis of the cat. The cysts are thick walled about $\frac{1}{2}$ inch in diameter and imbedded in the substance of the liver. The embryo contained in the cyst has the usual cephalic armature of a double row of hooklets the internal and larger are the less numerous. The total number seems to vary from 28 to 32. These circles of hooklets are situated at the apex of the conical head, and behind them are four oval suckers. The widest part of the worm is about 3 mm. from the head where they are some 1.75 mm. in breadth. Behind this point the worm slowly tapers and soon becomes thin, much flattened, and apparently consists of little but fibrous ribbon. The part behind the head is transversely wrinkled but there is no true segmentation.

In the hepatic interlobular spaces of one of these rats ova were found in large numbers. These ova measure .6 by .3 mm., and at each end have an opening somewhat like that in the ovum of a *Tricocephalus*. The egg coating is thick and in two layers which are closely applied to each other the outer is clear and transparent with coarse transverse marking and the inner more opaque, brown and uniform. The egg contents were shrunken and show no trace of definite structure. No other organs were sent to me. The eggs have no resemblance to those found in man by Dr. CATTO in a similar position in the liver as well as in other organs in the case of infection by the *Schistostoma* recently described by him.

NEMATODES.

Intestinal nematodes in man were not as common as in many parts of the tropics.

Those found were *Ascaris lumbricoides*, *Tricocephalus dispar*, *Oxyuris vermicularis* and *Anchylostoma duodenale*. A few Anchylostomes or traces of their presence were found in the great majority of the cases examined. These cases were Chinese and Tamils. Ova of the same parasites were found in the stools of 13 out of 21 Malay prisoners.

Though found in all races it was exceptional to find the parasites in large numbers. This is in marked contrast with most tropical countries where anchylostomes if widely distributed are also found in large numbers in a considerable proportion of the cases. This rarity of severe infections is probably to be attributed to the Chinese method of disposal of excreta. The fæces are either collected in large jars or passed into open cess pits. In either case the mass is attacked almost at once by dipterous larvæ usually of *Sarcophagi* which are deposited living on the fæces. The larvæ swarming in the previous dejecta also attack the fresh fæces.

Experiments were made by allowing such larvæ to feed on fæces containing various ova of intestinal parasites and these larvæ were then placed in a clean vessel and their dejecta examined. It was found that ankylostoma ova were completely destroyed in passage through the intestine of these larvæ whilst ova provided with thick shells, *i.e.*, *Ascaris Lumbricoides*, *Tricocephalus dispar*, and *Distoma sinense* were passed unchanged. A few larvæ were placed in glass vessels with a small quantity of fæces containing various ova in large numbers. The result of the experiments leads to similar conclusions. No anchylostoma ova or embryo were found in the mass after a few hours. The number of larvæ, their age and the relative amount of fæces are all points which affect the rate at which this total destruction of Anchylostome eggs takes place.

In the practical use either of open cess pits or of Chinese jars the number of larvæ of various ages near the surface is so great that anchylostoma ova, though in this climate they hatch under 48 hours, have little or no chance under those conditions of reaching the infective stage of free embryonic life. In the earthenware jars any larvæ that did arrive at such stage can only live for a few days in either pure or putrid fæces.

Eggs of the other parasites mentioned are not destroyed in this manner.

Tamils who pass fæces in the bush or amongst their gardens harbour the parasites in larger numbers as though no doubt larvæ are deposited on the fæces shortly after they are passed still many anchylostoma will have hatched out and escaped into the earth before the young larvæ have had time to pass the whole of the dejecta through their intestines.

Clinically cases of profound anæmia due to anchylostoma are uncommon in Malaya but do occur, and minor cases are more common. Out of 328 post-mortem examinations on Chinese the deaths due solely to this cause were only 2, but in 4 others there was reason to believe that the presence of these parasites contributed to the fatal result of the other diseases from which the patients were suffering. In the Tamils on the other hand 5 out of 32 deaths were attributed to this cause either alone or in the main.

Embryos of *Anguilula Intestinalis* were found in fæces on several occasions.

In the domesticated animals Mr. FORD, the Government Veterinary Surgeon, has observed *Ascaris Marginata* in the dog, and *Ascaris Suilla* in the pig, and *Oxyuris Curvula* in the horse.

In horses *Strongylus Armatus* was found both in the sexual condition in the cæcum and in the agamous form in intestinal tumours. It is probably injurious in those positions but more so in other situations.

In a bullock and a calf *Strongylus contortus* was found in large numbers but appears to be a rare parasite.

In dogs *Tricocephalus depressiusculus*, *Uncinaria trigenocephala* are found, and in the Oesophagus or in tumours in its vicinity the *Spiroptera sanguinolenta* is not uncommon.

Strongylus micrurus so common in the lungs of cattle in the West Indies and Central Africa has not been observed here.

In Indian buffalo calves but not in adults a *Syngamus* was found in the upper part of the larynx. The worms were firmly attached to the mucous membrane. The mouth has the usual strongyloid armature opening into a buccal expanded cavity. The opening of the oesophagus is guarded by 6 teeth. The oesophagus itself is very muscular and .9 mm. in length. The genital opening of the female is situated about the junction of the anterior with the second quarter of the body. The worms were red in colour and the male firmly attached in each instance to the female. The head of the male was free. In size and characters this parasite closely resembles *Syngamus trachealis* of domesticated birds. The length of females was 6 to 8 mm. and of the male 3.5 to 5 mm.

In one calf in addition to *Strongylus contortus* an *Anguillula* nearly twice the length of the human *Anguillula intestinalis* was found, and in addition a second *Strongylus* in small numbers in the abomasum.

The *Strongylus Contortus* is readily recognised even with the naked eye by the way in which the ovaries are twisted round the alimentary canal.

The head is unarmed and terminal. Two lateral cuticular spikes pointing backwards are situated .4 mm. from the head. The oesophagus is 1.5 mm. in length, a powerful muscular tube slightly dilated just above the junction with the intestine. The anus is subterminal and the tail is sharply pointed. There are two ovarian tubes. The vagina opening is in a deep sulcus surmounted by a fold of the cuticle and subjacent tissues at a point about one-fifth of the length of the body from the tip of the tail. The females were 18 to 20 mm. in length.

The males 9 to 10 mm. in length have a bilobed caudal pouch, each lobe strengthened by 4 ribs.

The two equal spicules including the trumpet shaped expansion are only .35 mm. in length.

The position of the vulva is that described in *Strongylus Contortus*, and not as in the more usual bovine species *Strongylus Convolutus*. The worms also are larger than that species. *Strongylus contortus* is a dangerous worm to sheep, the allied species in the goat and cattle are also dangerous. No other cause of death was found in the calf from which this and the two other species of worms were obtained. It had rinderpest about a month before but made a good recovery. The other *Strongylus*, which I propose to call *Strongylus Fordii*, was not present in such large numbers.

It is larger, had not the lateral cuticular spikes near the head, and the genital spicules in the male are of extraordinary length. The genital opening of the female is near the tail and is not surmounted by a projection as in *Strongylus contortus*.

The female, 21 mm. in length, greatest breadth .5 mm. The mouth is terminal and the cuticle surrounding it is thickened so as to form a circle of small rounded projections. The œsophagus, 1.9 mm. in length, is thick muscular and ends in a slight dilation before the marked junction with the intestine. The rectum is thin walled and terminates in the anus close to the sharp pointed tail.

The ovarian tubes are double, are not twisted round the intestine as in *Strongylus Contortus*, and end in a long thin walled vagina in which a single row of eggs is contained. The genital opening is marked by no protecting fold and is situated .5 to .6 mm. from the tip of the tail.

The male, 19 mm. long .44 mm. broad, terminates in a bilobed caudal pouch strengthened by ribs. The spicules which are protruded between the lobes for a variable length are continued in the interior, are distinctly tubular and terminate in a trumpet-shaped expansion. They are equal, and the total length is 6.2 mm. or more than $\frac{1}{4}$ the length of the body.

In both males and females the anterior part of the body for some 1 to 1.5 mm. is contracted and the cuticle somewhat thinner than elsewhere. To this part debris is adherent, as is usual in portions of worms such as *Tricocephali* which are plunged into the mucous membranes.

I can find no record of *Strongylus* corresponding to this worm, probably it is a new species. So many members of this genus are dangerous that this worm should be regarded with grave suspicion.

The *Anguillula* was not present in large numbers. Only females were found. They measured 5.5 to 6 mm. in length and .03 mm. breadth, and are probably a new species, *Anguillula Bovis*.

The most important parasite of domesticated birds found was *Heterakis Maculosa* which is found in enormous numbers in the intestine of certain groups of pigeons in Kwaia Lumpur. Treatment by powdered areca nut is highly successful. The mortality amongst such groups of birds untreated is great.

In monkeys various species of worms were found. In no instance did they belong to any of the species infecting man. They included species belonging to the *Sclerostoma*, *Oesophagostoma*, *Ascarides*, *Oxyurides* and *Tricocephali*. None of them appear to be of pathological importance.

FILARIDÆ.

In man the only filaria found were the embryos of *Filaria Bancrofti* (*Filaria hosminis sanguinis nocturna*). The blood of 100 patients (Chinese 75, Tamils 23, Malay 2) taken between 10 p.m. and midnight showed Filarial Embryos in 3. Of these 2 were Tamils and one Chinese.

Elephantiasis is observed from time to time but very rarely in this district. Dr. McClosky informs me that the cases of elephantiasis, admitted at the District Hospital in the last 4 years is only 3, though the total admissions for all causes amount to 17,804 in that period.

One Eurasian born in this country who had lived for some years in Madras had recurrent attacks of lymphangitis, slightly enlarged groin glands, and filaria nocturna were found in his blood. As his father died some

3 years ago in this colony and had had chyluria for some time with filaria in his blood the disease in the case of his son was probably contracted in this country and not in Madras.

Culex fatigans, was shown to be here, as elsewhere, an efficient intermediate host.

Considering that the population is mainly imported from Ceylon, Southern India and China, and that in many parts of these countries Filariasis is prevalent, the scarcity of these parasites amongst the inhabitants calls for some comment.

The explanation is, however, simple, as it is only in the larger settlements that the common efficient host is to be met with, and even in such places it is not often as numerous as in most parts of the tropics.

These larger settlements are of recent date and are steadily increasing in size. Little doubt can be entertained that with the continued increase in these towns, with the overcrowding in these towns and the increasing abundant provision of suitable breeding grounds for efficient carriers as *Culex fatigans*, the occasional introduction of cases of filariasis will eventuate in the infection of many persons and the addition of Elephantiasis and other filarial diseases to the number of important ailments in the country. These diseases were introduced into America and the West Indies, and now in places affect up to 20 per cent. of the population, Europeans, Asiatics and Africans alike.

In the domesticated animals filaria are common. The classification of the Filaridæ is very difficult, and several of the points laid down are difficult to determine. On account of the uniformity in the simple condition of parasitic life no doubt many structures are imperfectly developed. Even the characteristics of the family, the absence of an œsophageal bulb, presence of preanal papillæ, a single or two unequal spicules in the male and two ovarian tubes in the female, are not constant even in worms which are ordinarily included in the family. The inclusion in this description of worms which in other characters and in their habits correspond to the Filaridæ is made for convenience and whilst awaiting a sound comprehensive classification of the group.

Two species of Spiroptera were found. The *S. Sanguinolenta* already mentioned in dogs, and *Spiroptera reticulata* in tumors from near the shoulder in bullock beef. This Spiroptera is highly exceptional in the Bovidæ, but I am assured by Mr. FORD who found the tumors, that the meat was that of a bullock. Those worms are readily recognised by the spiral ridges in the cuticle. The interlacing of these ridges and processes from them gives a peculiar reticular appearance characteristic of this worm.

In the horse the *Filaria Oculi Equi* was found on several occasions, but is not very common and seems to be rare for long periods. On one horse a few sharp-tailed sheathless filarial embryos were found in the blood. Subsequent examinations no embryo could be found and the parental forms were not discovered at a post-mortem examination.

In the Bovidæ extra-ocular filaria are fairly common and correspond to the descriptions of *Filaria lachrymalis* it does not appear to cause more than a slight conjunctivitis.

The mature female filaria measure 2 cm. and are .18 mm. in breadth. The two ovarian tubes open into a dilated vagina .25 mm. in length. The genital opening is 1.1 mm. from the head. Ova not embryos were contained in the vagina. Mouth terminate and unarmed. Junction of œsophagus

with the intestine ill defined. Anus subterminal .3 mm. from the pointed tip of the tail. No males were seen. This worm is clearly distinct and from the extra ocular filaria of horse or fowls.

In the peritoneal cavity of almost every bullock but not in the buffalo *Filaria Cervina* are found. These worms are easily distinguished from the *Filaria papillosa* found in the horse by the presence of two blunt cuticular projections near the caudal extremity and the absence of the outer perioral papillæ. They do not cause any symptoms. One of the most interesting series of filaria are those found in the aorta. They occur in all the Bovidiæ examined, but whilst the largest species of the worm is very common in the Malay buffalo it is very rare in the Siamese bullocks.

A careful study of these filaria has been made by Dr. Tuck, and the reader is referred to his account of these worms.

The division of the ovarian tubes into four is most unusual. The peculiarity of the habitat of the adult and the absence of embryos from the blood are of great interest.

The effect on the vessels is marked. Usually they are greatly thickened, especially in the fibrous coat, and the aorta is frequently dilated whilst the interior surface is roughened and covered with ridges and strands of fibrous tissue representing the places where worms have been attached.

Small aneurismal dilatations are not uncommon. In spite of these changes the animals appear to be in good health, and Mr. FORD informs me that he has not known them in any case to cause death.

In dogs, *Filaria immitis* occurs, but is rare. Dogs thrive well in the country and it is only exceptionally that these worms are found and then usually in small numbers only.

Dr. TRAVERS informs me, however, that some 13 years ago the disease became epidemic amongst a pack of hunting dogs. Some 15 to 20 dogs died within a period of two months from the effects of this parasite.

This is of special interest as this filaria is conveyed from dog to dog via mosquitoes, the intermediate hosts, in the same manner as the human *Filaria Nocturna*. Under suitable conditions there is nothing to prevent a similar outbreak of *Filariasis* in man.

The important part played by animal parasites in the causation of disease amongst man and other animals of economic value is as yet not sufficiently fully recognised. The prevalence of these parasites in the Tropics is the main cause of the unhealthiness of such countries and the greatest obstacle to the development of a country.

Many parasites at first considered to be harmless or of small importance have subsequently been shown to be either dangerous in themselves or to be closely allied to species dangerous to other animals.

A thorough knowledge of these parasites and of the conditions essential for their existence and propagation is requisite for any attempts at prevention of diseases due to such causes and therefore as full information as can be obtained is the necessary preliminary to such attempts.

The constant stream of importation of men and animals harbouring parasites may at any time result in wide diffusion of disease.

Observations on some Worms found in the Aortas of Buffaloes and Bullocks.

GNOH LEAN TUCK, M.B., B.C., CAMB.

Research Student, Emmanuel College, Cambridge.

In the "Veterinary Record" of June 14th, 1902, there appeared a short paper on "Aortic Worms" by Mr. T. A. FORD, M.R.C.V.S., Government Veterinary Surgeon of Selangor.

Following up this interesting line of investigation, I have made a more extended study of the aortic worms. At least two different kinds are found in the aortas of buffaloes and in those of bullocks. In their several morphological and anatomical characteristics they belong to the family Filariidæ.

Previous to FORD's publication (*loc. cit.*), nothing had to my knowledge been written about these worms and the tumours found in the aortas of so many buffaloes and bullocks. I record here my own observations. The method adopted was as follows:—

Each day all the aortas of the buffaloes and bullocks killed at the local slaughter house were dissected out by the butcher and sent to the Institute for Medical Research for my examination. Each specimen was then opened with a pair of scissors along the median line of the ventral or anterior wall, because of the usual attachment of these tumours and worms to the posterior wall. The number of tumours and worms present was in each case counted, and the latter dissected out in water in order to find the frequency of males in them. This work extended from the first week in February to the first week in June, 1904.

FREQUENCY OF AORTIC WORMS AND TUMOURS IN BUFFALOES.

Altogether 93 buffaloes were examined, and the results are tabulated as follows:—

				Percentage.	
No. of Aortas examined	...	...	93	—	
Do. containing worms	...	...	67	72	
Do. with scars, cords and aneurysms	...	...	21	22.6	
Do. normal	...	...	5	5.4	
Total number of worms in 95 aortas	...	...	306.		
Average for each infected aorta	...	...	3.5	nearly.	

It should be mentioned that one worm corresponded to each tumour, but the former was occasionally torn off during conveyance, giving the impression that there was no worm. The head could, however, always be found inside the tumour if searched for.

The principal facts shown by the above table are the large percentage (72) of vessels which contained these worms, and the small number of aortas (5.4 per cent.), which were healthy.

A certain proportion of aortas (22.6 per cent.), though not containing any living worms, presented round oval corrugated spots, fibrous in character and rather deeply sunken in. These were once tumours. When the worm dies it shrinks up, with the result that a firm, white, fibrous cord is left.

When there are several of these scars, the cords from the different tumour remnants may be intertwined. These cords are the remains of the worms, and every intermediate stage can be traced.

Often these scars had so thinned the wall of the blood vessel, that small aneurysms were formed from them and projected outwards. Naturally these small aneurysms varied in number in different aortas. They were most frequent in the case of old animals, as in these the vessel walls are stiffer and contain less elastic tissue.

DESCRIPTION OF HOST.

The Malay or Siamese buffalo is a distinct species.

Externally it differs from the Indian buffalo in two main points:—

(i.) The horn is evenly flattened and ends in a sharp point instead of being rounded as in the case of Indian. So that if a transverse section be taken of both, the former will be rather angular in shape and the latter irregularly elliptical.

(ii.) The shape of the horn is only curved slightly inwards into a semi-circle and not twisted into a short spiral, usually from within outwards, as in the Indian buffalo. Mr. FORD states that: "The water buffalo is a ruminant averaging from 600 to 800 lbs. in weight. He passes most of his time, when not at work or feeding, in shallow muddy pools called buffalo wallows. His skin is usually covered with mud—a protection against the bites of flies, of which, in this part of the world, there are numerous and large species. When clean it is of dull black and in a few animals of a dirty pink colour and is sparsely covered with long bristles."

ANATOMY OF THE AORTA.

The Aorta of the buffalo is composed of:—

The common Aorta—the main trunk of the arterial system—which arises from the antero-superior part of the left ventricle; it passes upwards and forwards for nearly two inches and there divides into the anterior and posterior aorta.

The anterior aorta in the buffalo is very short, seldom measuring more than one inch in length. Two main branches spring from it—the left brachial and the right or brachio cephalic.

The left brachial artery supplies the left fore limb, whilst the right divides immediately into two—the right brachial proper supplying the right fore limb and the common carotid supplying the neck and head.

The posterior aorta is larger and longer than the anterior. It commences at the level of the 4th dorsal vertebra, passes upwards and backwards forming the aortic arch, and reaching the left side of the spine at the 6th or 7th dorsal vertebra. The dorsal aorta then lies in the posterior mediastinum, and after piercing the diaphragm becomes the abdominal aorta.

DESCRIPTION OF AORTIC TUMOUR.

An infected aorta when freshly opened from the ventral or anterior surface shows a variable number of irregularly rounded pearly tumours projecting into the interior of the vessel. Sometimes there is only one solitary tumour. Rarely there are as many as 20, but the usual number is from 2 to 5. These are confined to the posterior aorta, but in 7 out of the 67 cases recorded above these tumours occupied the anterior aorta as well.

In six of these seven cases, the number of worms in the anterior aorta was one whilst the remaining one contained three.

The distribution of worms in these seven cases was as follows:—

WORMS IN		TOTAL.
Anterior Aorta.	Posterior Aorta.	
1	3	4
3	17	20
1	14	15
1	3	4
1	7	8
1	17	18
1	—	1

In the last case the only worm present was in the anterior aorta.

The tumour measures from .5 to 2 cm. across, and its surface, especially in the lower half, is of a smooth pearly lustre. The base is circular and the whole tumour is conical in shape.

From the lowermost point close to the place of attachment of the tumour to the intima springs the worm, varying in length from 8 to 30 cm., but usually 22 to 25 cm. when sexually mature. In life the worm floats about in the blood and follows the direction of the flow, *i.e.*, backwards. The few worms situated in the anterior aorta are, however, attached to the anterior part of the tumour and their bodies carried forwards by the blood stream either into the common carotid or the brachial.

These tumours are hard and somewhat fibrous to the feel but their coats are quite smooth and form a striking contrast to the rest of the intima which is often roughened.

The worm may be dissected out of one of these tumours by means of dissecting needles with cutting edges. The tissue of the tumour is carefully torn away from below upwards along the path of the hidden worm and any tough tissue encountered is cut away with fine scissors.

The contents of the tumour consist mainly of granular debris and calcareous particles. The tumour also contains the head of the female worm, and one or more males curled many times round themselves. They may easily be pulled out of their loose surroundings. When males are present the granular debris, if mixed with a drop of normal salt solution, shows a large number of free embryos.

The portion of the female hidden inside the tumour is the narrow head end. On its entrance it receives a firm fibrous sheath from the lining of the tumour which is somewhat difficult to dissect off. The size of the worm tapers gradually as it is traced forwards until at the mouth it is not more than .5 mm. in diameter. The tough sheath surrounding the worm is firmly attached to the fibrous walls of the tumour but is lost towards the head, so that this part of the worm, much narrower than the other parts, is at liberty to move about amongst the granular debris.

Once the sheath is removed the rest of the worm will come off readily. The ensheathed portion is bent on itself and usually assumes the form of a letter S.

The portion bound down by the sheath measures about 5 mm., forming a fixed collar round this part of the worm whilst the free head portion reaches a length of 20 mm. The part of the worm inside the tumour thus measures about 25 mm.

Section of Aortic Tumour.

Sections of the aorta with attached tumour both transversely and longitudinally to the points of entrance of the worm demonstrate the following points:—

The epithelium which lines the outer surface of the tumour consists of a layer of flattened cells continuous with the endothelium of the intima. Just at the angle where it actually merges into the intima this layer is much thickened, thus forming a triangular area, but the cells still maintain their flattened character.

Beneath this endothelial layer is a dense mass of cells irregularly distributed and bound together by some thin bands of fibrous tissue. The nuclei of the cells nearest the surface are deeply stained, whilst those lower down are more or less degenerate in character, and here and there a few strands of elastic fibres (stained yellow with Van Gieson) may be encountered.

Amongst this loose granular tissue the worm is often seen cut transversely. Whilst thus *in situ*, its structure may be studied with greater ease than in a specially prepared one obtained from the dissected out worm.

The tumour is separated from the middle wall of the aorta by a thin band of elastic tissue which extends from one end to the other. The minute structures of the aorta differ somewhat markedly from those of a healthy one. Instead of the long continuous bands of elastic tissue interspersed between the fibrous strands in the tunica media one meets with short bands arranged irregularly throughout, and on the whole there is less elastic tissue in the layers of the morbid aorta than in the normal one.

The point of entry of the worm, as seen in a section of the tumour cut parallel to the worm, possesses no special significance. The sheath encircling the worm is well marked as a deeply stained fibrous band, and surrounding this are the usual loose granular masses composed of living and degenerate cells.

Remote changes in the Aorta.

In 21 out of the 93 buffaloes' aortas examined scars representing tumours which had shrunk up after the death of the worms, were found. It must be noted at the same time, however, that these scars were sometimes found side by side with fresh tumours containing living worms. Hence it is evident that the formation of these tumours does not all take place at the same time, or certain less favoured ones perish earlier than the rest. These degenerated tumours are met with in all stages from the unchanged tumour with attached dead or more or less shrunk worm to a deeply indented scar from which springs a white fibrous cord representing the remains of the worm, often in many fragments, joining with other remnants in the neighbourhood to form a loose reticulated mass.

Section of an Aortic Scar.

A section from one of these scars shows irregularly serrated edges and a surface covered by a thin epithelium consisting of small flat cells continuous with the endothelium of the aorta.

The thin layer of muscle fibres in the internal coat is largely replaced by stout fibrous tissue. The tunica media and externa also contain much fibrous tissue with a corresponding scarcity of elastic fibres. No remnant of a worm has been found in the scar tissue.

Altogether the morbid aorta is thickened but there is a loss of the elastic element in the wall. This paves the way for the formation of small aneurismal scars at the site of the degenerate tumours.

These small aneurysms are formed by the excessive thinning and the diminution of elastic fibres in the walls of the aorta in these regions. Small red clots are occasionally found in these pouches, but the fibrinous layers seen in the clots of human aneurysms indicating attempts at filling up the cavity have never been met with. These aneurysms are so small in size (seldom reaching a depth or a width of more than 1.5 cm.) that they probably play very little part in the derangement of the arterial flow or lead to rupture.

Naked Eye Appearances.

The female is a round worm. The youngest specimens found were about 6 to 7 cm. in length, and when adult 25 to 30 cm. At its head end it is attached to the tumour whilst the other extremity is free and moves about in the blood stream.

The colour is white and translucent at the tapering head end (length usually 20 mm.) but lower down the many coils of the distended uterine tubes render the worm intensely opaque. The alimentary canal can be seen as a thin brown streak. The body gradually increases in thickness as the narrow head portion is left; the diameter is greatest about the middle of the worm, whence it gradually decreases in size again and ends in the tail. The posterior portion is quite transparent from the absence of the coiled tubes (10 to 12 mm.).

In the fresh state the worm is very active. When placed in water it wriggles to and fro and even when severed in many places each has the power of movement by itself, especially the tail and head. The worm has lived up to the second day when separated from the tumour. When partially dried and apparently dead the addition of water will often revive it.

Lateral Aspect.

The cuticle is firm and serrated, but there is no segmentation. This serration is quite superficial, the deeper structures showing no signs of it at all. The superficial markings extend along the whole length of the worm from the head to the tail.

Beneath the cuticle the two layers of the muscular layer may be easily differentiated under the high power.

At the mouth the longitudinal layer seems to be reflected on to the muscles of the œsophagus, thus forming an angle at their point of junction.

A little lower down, about 5 mm. from the mouth, two gland-like structures appear to be attached to the œsophagus and held in position by some transverse fibres from the circular coat. These may be the salivary glands. Towards the tail the muscular layers grow somewhat in thickness, and where the intestinal canal terminates in the anus, these muscles are continued up to the very end as a firm band.

The Digestive System.

The mouth is anterior and surrounded by an oral ring. In the living state this mouth is very retractile, coming in and out of its ring with great vigour. It is continued into the œsophagus, also an extremely retractile tube. This measures quite 7 mm. in length, and appears in the fresh specimen as a white opaque tube. In fact so retractile is it that when stained and preserved in glycerine it shrinks into a spiral tube looking wavy instead of straight. The canal itself is very narrow and appears as a slit between the thick walls.

Along its long course the œsophagus is crossed over at many places by the uterine tube, which is the only other visible tube in this part of the worm. The œsophagus in the female is a very long tube.

After about 7 mm. the œsophagus becomes suddenly dilated into the bulbous stomach which as such is continued further on as the intestine without, however, any visible differentiation. The intestine is nearly straight and terminates in the anus.

The stomach and intestine are brownish-red in colour, instead of opaque like the œsophagus. This is due to the presence of half digested blood present along its whole length. Under the microscope the contents of this part of the intestinal canal show large numbers of corpuscles which have evidently been absorbed from the buffalo's blood.

Beyond the two solitary glands opening into the œsophagus (.5 mm. from mouth, ? salivary glands) there is no evidence of any other opening into the alimentary system along its whole course.

The anus is subterminal in the female and situated about 2 to 3 mm. from the tip.

Nervous System.

At the oral ring there is a circular cord-like structure with one longitudinal branch springing from it on either side. But these two longitudinal cords cannot be traced far down, as they disappear in the meshes of the longitudinal muscles. In transverse sections, however, the two cords can be made out with tolerable accuracy lying in the midst of the longitudinal fibres. No gangliiform swelling has ever been noticed.

GENITAL SYSTEM.—FEMALE.

The sexes are separate, and the male is smaller than the female. The dissection is a rather delicate operation especially in its upper part. A very fine pair of scissors and forceps are necessary and the whole process should be carried on in water. On looking at the upper tapering portion of the worm through the undisturbed cuticle, one finds a thin tube lying side by side with the brown alimentary canal. This is the single uterine tube, and further back are the coils of the distended ovarian tubes. These are intensely opaque from the distension with many embryos.

On splitting the cuticle this delicate ovarian system can be separated out, and the few thin bands binding it to the cuticle may easily be torn through. In the distended areas the ovaries are liable to be ruptured, making the water quite milky, but this is an unimportant accident since the most essential parts of the apparatus will have been seen.

The genital or vaginal opening of the aortic worm of the buffalo is situated near to the head (.65 to .75 mm. from the oral aperture). It lies on the ventral surface and under exceptional circumstances can be made out as a distinct slit.

These rare occasions occur when the living embryos are seen escaping from the vagina.

Through this opening hundreds and hundreds of mature embryos with their sheaths already cast off escape. They come out in ones or twos, sometimes head first, sometimes tail foremost, and sometimes in coils. When more than one, the embryos may be seen struggling against each other to get through. During life the uterine tube may be noticed to terminate abruptly at this region but the genital opening is not obvious and there is no papilla. In the fresh state it can be recognised by:—

(a.) The escape of embryos.

(b.) A discharge soon after the escape of each embryo, consisting partly of fluid and partly of granular debris.

(c.) The detection of a narrow passage representing the vagina which can be made out by careful focussing through the thickness of the worm. This leads to a slightly more dilated tube containing embryos all very active and all striving to reach the outside first. The whole view altogether presents a striking picture.

As far as can be seen, although the opening at ordinary times is not evident, the cuticular muscles must be specially developed at that point so as to open automatically for the passage of the embryos.

In a successful preparation two or three of these embryos may be fixed *in situ* as they are escaping from the genital opening. This preparation can be made by running under the coverglass a saturated solution of Mercury Perchloride at the right moment, then washing with water, and clearing with glycerine. The worm is rendered more transparent now, but the various embryos are not so easy to make out as they lie inside the single uterine tube. The genital opening, however, is interesting. At the site where the embryo or embryos are on the point of emerging, there is a swollen papilla-like process projecting outwards and encircling the embryos tightly.

Picrocarmine and other basic stains bring out these points more clearly. The genital aperture leads to the vagina, a thin narrow passage merging

imperceptibly into the single uterine tube. The walls of this tube are thicker than elsewhere. The single uterine tube traverses the whole length of the tapering portion of the worm (20 mm.) as well as a portion of the body proper up to a point 40 mm. from the mouth. Thus the length of this single uterine tube is quite 40 mm. in length. The contents of this tube are mature embryos whose shells have been shed, and it is these which give such a lively appearance to this part of the living worm.

The uterine canal at this juncture swells slightly in size, the swelling measuring only 5 mm. in length. It then divides into two separate tubes, each of which again soon subdivides into two, making thus four separate tubules altogether. The distance from the bifurcation of the single tube to the point where these four tubules are formed is 20 mm. The four tubules which we may call the ovaries or ovarian tubes are much larger than the parent tube; in fact quite four times as broad. The ovarian tubes are twisted round one another in a spiral manner enclosing amongst them at places the brown coloured intestine which can easily be distinguished even through the undissected cuticle of the worm. These ovaries extend over a great length and terminate within a few mm. of the tail. There each tube ends blindly.

In the adult female worm these ovarian tubes are always engorged with ova in different stages of development. The youngest ova are formed in the most distal portion from the budding of the germinal cells of the epithelium. As these ova travel forwards they get fertilised and undergo further development. So that as we travel forwards from the tail end to the genital opening, we find these ova in various stages of development. The mere simple cells at the distal extremity become encapsuled cells further on, encapsuled young embryos still further on, and finally young wriggling free embryos with shells torn off in the single uterine tube. An instructive method of studying these various processes is to get a drop of the contents of the ovaries from different parts of the genital apparatus and examining them fresh.

The total length of each of the ovarian tubes is not easy to determine, but it cannot come approximately to less than twice the length of the worm for not only are these tubes twisted, but are at places bent on themselves so as to occupy the body cavity to greater advantage.

In fact so much pressure is exerted on the cuticle by these distended coils of the ovary, that a little rough handling is often quite sufficient to burst the cuticle and rupture one or more coils, resulting in ova and embryos escaping in large numbers.

Even submersion in a fixing fluid like weak formaline (2 per cent.) or alcohol (30 per cent.) very commonly causes the cuticle and ovarian tubes to rupture.

TRANSVERSE SECTION.

A transverse section of the worm about its middle shows little but the ovaries. These are so engorged with ova and embryos that every other organ is displaced to one side by them.

A better idea of the relative position of the component parts is obtained when a section of the tumour itself is cut with the worm *in situ*, i.e., towards the cephalic region.

Outside is the tough sheath surrounding the worm, next to it lies a narrow cuticular layer; beneath this is the circular muscular coat and then the longitudinal; the latter is the thicker. It is interesting to note that these layers are thicker over the dorsal and ventral than the lateral regions. No special coelomic cavity lined by a special epithelium seems to exist although there is a large open space where the alimentary tract and the four coils of the ovary lie.

The intestinal canal may be distinguished by its flattened shape and by the cubical granular epithelium evenly laid out. The uterine tube, on the other hand, presents a peculiar uneven epithelium lining the interior. This is due to the cells projecting inwards with their large nuclei (seen best under the one-twelfth oil immersion). These cells are never many, and in section usually between 6 and 8 are seen. External to this epithelium is the smooth muscle layer which is evenly distributed. Within the lateral longitudinal muscular layer two small peculiar structures looking like nerve cords are sometimes seen cut transversely.

There is no regular water-vascular system.

A section of the worm at the tapering portion close to the head reveals the œsophagus and single uterine tube, slightly thicker here than elsewhere, lying side by side, whilst the other structures diminish in size correspondingly. Towards the tail end where the ova are formed, the ovarian tubes are more or less solid in character due to the rapid proliferation of the cells of the germinal epithelium.

OVA AND EMBRYOS.

The ova and embryos are not unlike those of many other species of *Filaria* in their appearance.

In all the young embryos of fertilised ova, a thin capsule completely encircling the contents is present. This capsule is oval and possesses sometimes a pointed spicule at one extremity, more often one at both extremities (? micropyle). What the functions of these spicules are it is hard to understand, for when the embryos are fully developed they break through their capsules and pass out through the genital opening into the interior of the aortic tumour and live amongst the loose granular debris. Their eventual destination has not yet been traced.

The free embryos are found scattered sometimes in very large numbers, sometimes in scanty numbers inside the aortic tumour.

When living, they are extremely active and wriggle out of the genital opening after the most peculiar contortions. Once outside, they struggle hard in the surrounding media, now coiled up, now straightened, and ever restless. No special parts or organs can be detected. When fresh, the whole embryo appears as a refractile granular mass of living substances. Under the oil immersion no œsophagus or any definite structure can be seen beyond refractile granules of various size, which are not blackened by osmic acid and hence are not fat globules.

In a stained preparation obtained from some of the contents of aortic tumour in which these embryos are present, the various structures may be more closely observed.

The length of an embryo is 292 to 325 u. (.29 to .32 mm.) and breadth is 3.5 to 4 u.

Its head is somewhat knob shaped when seen from above downwards, but occasionally presents a hooked appearance when viewed laterally. Just below the head is the slightly constricted neck which is continued as the body more or less uniform in character until the tail is reached, when it tapers rapidly to a mere filament.

There is a rudiment of a mouth on the head bounded by two oval deeply stationed nuclei. No distinct structure representing an œsophagus could, however, be seen, unless we regard the rather indefinite interval between two rows of rod shaped nuclei for a short distance as one. The nuclei are arranged in an unusual manner. At the head portion very few or none are encountered. From the neck downwards for a distance equal to one-tenth of the whole length of the embryo these are rod shaped in character and are placed in the form of two parallel rows, thus making the intervening space appear as an œsophagus. This, however, is not constant, and a single row of 5 to 6 rod shaped nuclei may be seen occupying the centre of the neck. Lower down the nuclei are oval and are arranged irregularly, sometimes in twos, sometimes in threes, but their longest diameters are always parallel to the length of the worm. There are interruptions or gaps in this nuclear core where nothing but faintly stained protoplasm is seen.

Towards the tail, the nuclei are arranged in single file. The tail itself is finely drawn out and for 15 to 20 u. or so is occupied merely by protoplasm without any corresponding nuclei.

MALE AORTIC WORM OF BUFFALO.

The male aortic worm of the buffalo is found coiled up within the tumour. Unlike the female, no portion of its body is visible in the unbroken mass except occasionally, when the head may be seen projecting through the soft part of its covering. Each female is usually associated with one male within a tumour, but two or three separate males are common, and on one occasion as many as eight separate males were removed from one tumour though only one female was present.

This male worm lies loosely coiled up amongst the granular contents of the tumour, so that it is quite easy to remove it. On tearing away the loose tissue of the tumour, this is usually the first living structure seen. Once found, it can be pulled out without any difficulty. It may, however, be mentioned that not every tumour harbours a male worm, especially when the female is young or very old. In about 70 per cent. of the tumours dissected one or more males have been found. When the males are absent, no embryos are ever found inside the tumours. The male is a much smaller creature than the female. It measures from 45 to 50 mm. in length as compared with 200 to 300 mm. in the adult female, whilst the greatest width is never over .3 mm. as compared with 1.5 mm. in the female.

When freshly dissected out and placed in a dish containing normal saline solution, it coils and uncoils itself in a regular manner, but does not move about from place to place. The head and tail portions are the most active.

ALIMENTARY CANAL.

The mouth is surrounded by an oval ring. The rest of the alimentary canal differs from that in the female in that :—

The œsophagus is not so retractile, is much shorter, only about .6 mm. in length.

2. The intestine is scarcely ever brown in colour and does not contain blood.

3. The alimentary canal is straight, there being no distended coils of the testis to displace it.

4. The rectum ends in the common cloaca in conjunction with the vas deferens. The last deserves special mention.

The anus, merged into the cloaca, is subterminal and distant about .15 mm. from the extremity of the tail. Its details cannot be distinctly made out, being largely hidden away by the thick spicule and its sheath.

The muscular system is less developed in the male and the peculiar arrangement of the fibres is not so marked.

Nothing definite can be made of the excretory or nervous apparatus.

GENITAL SYSTEM.

The genital system is less complicated than in the female. There is only one testis—a long narrow organ running parallel to the intestine. Above it reaches to about the middle of the body; downwards it terminates in a vas deferens which differs in no wise from the testis beyond the fact that it is hollow and slightly narrower. Within the testis, large numbers of refractile cells may be seen in the living worm. These are the spermatozoa. They will be described more fully later on.

The vas deferens is continued as a stiff spicule which is very retractile. This—the anterior spicule—measures .22 mm. in length, and in the living stage may be seen to project in and out by means of the strong muscles attached to it.

Lying usually behind it, but occasionally by its side, is a shorter structure of a similar shape. This is the posterior spicule (sheath of the penis), and its length reaches .12 mm. This latter spicule is apparently not connected with the vas deferens. It is also moveable but not so active as the anterior spicule (penis proper) and can move independently.

The anterior spicule is a trumpet shaped organ. Where it is continuous with the vas deferens it is irregularly funnel shaped, the diameter being just under .03 mm. (30 u.). As it proceeds outwards, it tapers gradually until it finally ends in a slightly bulbous projection and then a sharply defined filament. The cuticle round the point of emergence of the two spicules is raised forming a prominent ring.

Two smaller papillæ may be seen lying in front of the opening. One is situated just anterior to the ring, and the other—a more easily detected one—30 u. or .30 mm. still anterior to this. There are, besides the above, one or more post-anal papillæ, but these cannot always be detected.

The hinder portion of the male worm is curved on its ventral surface, along which a distinct groove may be seen running longitudinally in the centre, to admit of the passage of the two spicules.

It will be seen that the arrangement of the genital organs in the male and female worms is best adapted amidst their surroundings for their several functions. The openings of both are situated inside the aortic tumour, that of the female being in the constricted portion close to the mouth, and that of the male being at the posterior extremity but well within the reach of the

female. Copulation takes place inside the tumour and the embryos produced are also discharged into it to be distributed later on to some hitherto unknown part.

SPERMATOOZOA.

The sperm cells produced by the testis are oval, spindle shaped, or cross shaped in appearance. Their largest diameter is 10 to 12 u. Each possesses an intensely refractile nucleus surrounded by granular protoplasm. These cells may change their shape from one form to the other, but no independent movement has been seen. They are formed in the testis, and when mature pass down the straight vas deferens to be ejected through the narrow aperture in the anterior spicule. When seen under the microscope during the ejection of these cells, they are noticed to come out in strings, being attached to one another by means of some sticky substance so that they often appear as a bunch of grapes hanging on to the ventral surface of the tail.

When stained, these sperm cells show a deeply coloured nucleus situated usually in the centre and occupying a large part of the cell.

When in groups, these cells may each take a pyramidal form, being united together by delicate threads, the whole picture looking indeed like a bunch of grapes. No cilia or appendages of any sort have been seen.

OTHER KINDS OF TUMOURS IN THE BUFFALO'S AORTA.

Another form of tumour—the round blind tumour common in bullocks—is in rare occasions found in buffaloes. Out of 93 buffaloes' aortas examined, in one solitary case this condition was found. In this instance, three round blind tumours were scattered over the aorta, one large and two small. A female of the worm to be presently described was found in the larger tumour but no male.

AORTIC WORMS OF BULLOCKS.

A totally different species is found in the bullock. The tumour instead of being much raised and irregular is flattened and rounded in shape; it is quite blind as far as the outside appearance is concerned. No large suspended worm emerges from it; and the female worm when dissected out is of a yellowish colour. It is imbedded in a dense stroma of fibrous tissue and moistened with thickish yellow liquid.

Like the buffalo, two main kinds of bullock are met with in the Malay Peninsula, namely, the Indian and the Siamese, though cross breeds are not uncommon. The Indian bullock is a better developed and finer looking animal, with long straight rounded horns standing almost parallel to one another. The Siamese or native bullock, on the other hand, is a smaller beast with short, rather curved, rounded horns pointing towards each other at the free ends. The Indian bullock weighs from 400 to 500 lbs.; the Siamese slightly less.

In addition, the Indian cow is the main source of the local milk supply, whereas the Siamese cow provides little or none.

Both varieties live much in the same way, but besides grass the Indian bullock, which is more expensive, gets a liberal supply of broken rice boiled down to the consistence of gruel.

Unlike the buffalo the bullock is not fond of shallow mud pools or dirty river banks; in fact it has to be washed regularly by the keeper, and hence the conditions under which the buffalo and bullock live differ widely. At the local slaughter house, imported Siamese and native bullocks principally are killed. The Indian ones are too expensive, but the few aortas of the latter that have been examined show no deviation from the usual rule as regards the frequency of worms within them.

The anatomy of the bullock's aorta differs in that it is smaller in size, the walls are not so thick, and there is less abundance of tough elastic tissue.

The distribution of the various branches of the thoracic aorta is just the same as in the buffalo (*see description above*). On opening an infected aorta one usually finds round blind projections with no trace of the long opaque freely swinging worms. A more careful scrutiny, however, brings to light yellowish wavy lines or serpiginous tracks running along the length of the aorta. The tumour is smooth and shiny, yellowish white in colour like that of the rest of the aorta, and measures from 5 to 15 mm. in diameter. No trace of any worm can be noted immediately around its neighbourhood, but a few millimeters away the yellow wavy serpiginous tracts described above are always seen running down the length of the aorta for a variable distance. Some do not proceed straight but are bent at an angle, whilst portions of the same may even lie almost transversely. In fact so very convoluted are these wormy tracts that when present in large numbers the whole aorta may feel much beaded to the touch.

Occasionally the tumours are shrunken up, leaving a non-projecting surface, but the yellow wavy worms lying as they do immediately beneath the intima are quite distinct.

Even when these round blind tumours and serpiginous tracts are not present, round white scars may often be seen scattered over the intima of the aorta.

The proportion of smooth healthy aortas in the bullock is greater than the corresponding ones in the buffalo, as the following table shows:—

	Percentage.			
No. of Bullock's aortas examined	155	...	...	...
" " with Tumours	39	...	...	25.2
" " Serpiginous tracts	25	...	...	16.1
" " Scars and wrinklins	32	...	...	20.6
" " of healthy one	59	...	...	38.1
Total number of tumours in 155 aortas, 157.				
Average for each infected aorta 1.6.				

ROUND BLIND TUMOUR.

The round blind tumour was found in about a quarter of aortas examined.

To demonstrate the contents is not a simple matter of dissection, as the tumour has to be torn away piecemeal.

At a depth varying from .75 to 1.25 mm. from the surface a softer layer is encountered. This lines a small cavity consisting of loose tissue bathed in a minute amount of yellowish fluid. Inside this liquid the head of the female worm is usually seen. It may be more or less easily traced out as a yellowish structure for 5 to 7 mm. After that more tearing of the surrounding dense tissue has to be done in order to follow out its course. The firm adherence of the worm to the various layers of the vessel wall and its exceedingly wavy course make it impossible for one to dissect it out whole, so that at 20 or 30 mm. from its mouth the worm is usually torn off and the full length cannot be fully ascertained. On thing is, however, certain, and that is the fact that the worm whose head portion is enclosed within the round blind tumour is continuous with the yellow serpiginous tract running along the aorta. It is almost always at the beginning of this wavy line that the worm is torn off.

Although the majority of round blind tumours are situated in the interior of the vessel it occasionally happens that a large round stiff projection is seen on the external coat of the aorta. When dissected this external tumour proves to be of the same structure as the smooth tumour found inside. The same yellow fluid and yellow worm are harboured inside it.

It should, however, be mentioned that in addition to the yellow female worm, the male element also exists in certain tumours alongside of it. The presence of the latter is not so frequent in bullocks as in buffaloes and it is harder than even the female to isolate from the surrounding fibrous mass. Microscopically the male worm is thinner and more delicate; its colour is white and opaque instead of yellow.

The usual rule is for one male to be harboured alongside a female, but on rare occasions two males may be found inside one tumour. More frequent than not, out of the serpiginous tracts parts of both male and female worms may be extracted wound round one another.

The yellow liquid contains granular debris and broken down tissue with a variable number of ova and embryos, some free, some still encapsuled. The free ones are usually very active, and present in the fresh state no marked features different in any way from those found in buffalo tumours.

OTHER KINDS OF TUMOURS IN THE BULLOCK'S AORTA.

Besides the round blind tumours two other kinds have been noted in the bullock. One of these takes the form of a short blunt prolongation downwards from the centre of a smooth tumour in the aorta. This probably represents the remains of a worm of the same species as that commonly found in the buffalo. A dissection of its contents confirms this opinion, for within the stump may be found the calcified remains of an old worm. Five of these peculiarly shaped tumours have been met with altogether.

Besides the above, one exceedingly interesting tumour in the form of a papilloma has been found. This papilloma is irregularly shaped, being more bulky below than above, and is attached to the aorta by a short stoutish stem springing from a swelling lying on the aorta. The projection and stem are no doubt the remains of the pearly tumour and worm described above (buffalo's) whilst the reddish brown papilloma is no more than a large clot of blood which has been formed gradually on the stem.

A section of this pseudo-papilloma reveals an irregularly formed fibrinous structure in the meshes of which a few small blood vessels may be seen. The tumour is covered by no specially developed epithelium, a single but interrupted row of flattened cells more or less representing it.

In addition to the badly stained fibrinous stroma, there are present a few small rather vascular islands of deeply stained cells scattered in the centre. These are no doubt connective tissue cells which are not yet completely organised.

No worms or embryos can be noticed anywhere inside this tumour.

Scars and Wrinklings of the Aorta.

Although the percentage of healthy as compared to morbid conditions of the bullock's aorta is great (being 38.1), there are often met with old scars and wrinklings of the vessel representing tumours and serpiginous tracts of worms which have "shrivelled up." These occurred in quite 22.6 per cent. of the cases examined. They present no special points of interest beyond the fact that the scars are only slightly depressed and are usually white and fibrous.

Lastly the large long suspending worms so common in the buffalo were present in two cases out of 155 bullocks' aortas examined. In the first case one tumour was present; in the second three tumours and worms. Being so rare no attempt was made at dissecting the latter, which was preserved for museum purposes, but a search for a male worm and embryos in the first case gave negative results. It was not possible to trace the history of the two bullocks which possessed the buffalo worms within them.

THE FEMALE WORM IN BULLOCK'S AORTA.

Its total length has never been measured as it is impossible to dissect it out completely from the dense tissue of the aorta in which it is closely enveloped. Its width is nearly the same throughout, being not much greater in the body than at the head end. The following table gives a comparison of the male and female worms as found in the buffalo and bullock.

BUFFALO'S WORM.		BULLOCK'S WORM.	
Length.	Breadth.	Length.	Breadth.
Female 200 to 300 mm.	{ Head .29 to .30 mm.	Over 60 mm.	{ Head .25 to .27 mm.
	{ Body 1.25 to 1.5 mm.		{ Body .350 mm.
Male 45 to 50 mm.	{ Head .32 mm.	42 to 45 mm.	{ Head .116 mm.
	{ Body .34 mm.		{ Body .146 mm. also in another specimen { Head .075 mm. { Body .175 mm.

The head of this worm is situated in a minute pool of yellowish viscid liquid, in which embryos, if any, may be found. It is yellowish in colour, and since the whole body is firmly bound down with the exception of the first few millimeters at the head end, its movements are naturally confined to this part and they are withal slow.

Lower down where the serpiginous tracts are seen, its body is much bent many times on itself and consequently distorted, the whole arrangement producing the appearance of those beaded wavy lines one notices from the interior of the aorta.

So far the whole length of the worm has not been traced out on account of the firmness with which it is bound down to the adjoining structure. Hence I have not been able to find the tail end or the exit of the alimentary canal.

DIGESTIVE SYSTEM.

The mouth is not surmounted by any obvious structure. In the fresh state it is very active, moving along with the œsophagus both from before backwards and from side to side. The worm is narrowest in this part of its body.

The œsophagus extending from the mouth to the stomach is a narrow structure and measures .58 to .62 mm. in length. It is thin-walled and presents a striking contrast to the thick muscular stomach and intestine following it. No glands are seen opening into it. There is only a very faint differentiation between the stomach and intestine, so that it is not quite evident at which point the stomach is merged into the intestine. The intestine follows the wavy course of the worm along its whole length as far as has been traced. There is no variation in the size of the gut all along its course.

GENERATIVE SYSTEM.

It differs very markedly from the one in the buffalo in possessing *only two ovaries* or ovarian tubes instead of four.

The genital aperture is situated on one side of the body about .90 to .95 mm. from the mouth. In the first state it is not marked by any special papilla, but the occasional escape of ova and embryos indicates its exact position. In a preserved glycerine specimen the uterus with its contents may be seen to terminate here.

The uterus is continued for 10 to 15 mm. before two ovarian tubes open into it. These are of the same diameter throughout, and are not distended like those met with in the buffalo. They are slender but may contain large numbers of ova and embryos, both encapsuled and free.

These two tubes, if traced towards the distal end, become a solid mass of cells. The appearance in transverse section will be described later on.

The ova are not very different from those found in the buffalo. They are round or oval, measuring from 10 by 15 u. in the youngest stage to 20 by 40 u. in the fully developed but still encapsuled embryo. Here also we notice the spicules at one or both ends of the capsule surrounding a hyaline protoplasm with very granular embryo.

As in the buffalo's worm, so in this one also the different stages of the ova may be traced as one proceeds from the distal end of the ovary, through the narrow ovarian tubes to the uterus. From single cells one comes to simple cells showing nuclear division, and past this to the same with their capsules thickened. Next, rudiments of the future embryos are encountered until, near the single uterine tube, one finally meets with the free embryos which have broken from their capsules and are wriggling about in an active manner.

Finally these free embryos escape from the body through the genital pore.

TRANSVERSE SECTION OF FEMALE WORM.

When the worm is cut transversely *in situ* in the wall of the bullock's aorta it is seen to invade principally the outer part of the middle coat. Here one notices that it is cut in many places, each being enclosed in a bed of fibrous tissue without, however, any special defining layer.

The worm is much shrunk up and distorted, but this is due to the effect of alcohol, etc.

Outside is the cuticle, whilst next to it lies the two muscular layers—circular and longitudinal. Both, especially the latter, are poorly developed.

Attached by loose tissue to this body wall is the alimentary canal also much flattened and distorted by the distended tubes of the ovary, which, as I have said above, are two in number. The structure of these tubes, as they are traced from the true ovary downwards (*i.e.*, mouthwards) is interesting. At the upper end is the somewhat thick muscular wall lined by a rather dense irregularly projecting epithelium (*see figure*).

The ova when mature are, as it were, budded off this epithelial lining, retaining of course half the nuclei, and appear as clusters of two or more oval cells at places. That part of the epithelium from which the ova have been detached is shorter than the rest, and hence the peculiar zig-zag arrangement of the cells. Lower down the ovarian tube changes somewhat in character, the muscular wall being now thicker and the epithelium more even. Groups of ova may also be seen in the lumen.

Lastly, when fertilization takes place, these ova undergo the usual changes, so that embryos in all their various stages may be met with in the two uterine tubes, still enclosed in their respective capsules. By the time they reach the single uterine canal, the capsules will have been left behind, and we encounter the active wriggling embryos finding their way out of the body through the small genital opening.

No other special structures could be distinguished in a transverse section.

THE MALE WORM.

The male worm is found in less than half the tumours dissected and hence is rarer than the corresponding one in the buffalo. Besides that, it is also harder to dissect out, being smaller and more firmly adherent to the tissues in which it is hidden.

This worm is a white thread-like structure, and when found is seen to be closely wound up with the female of the same tumour. Its white

opaque colour contrasts well with the larger yellow coloured female worm. Owing to its shorter length the male worm can be more easily traced from the head to the tail.

When thus completely dissected out it is found to measure from 42 to 45 mm. in length. The maximum width in the centre of the body is only .146 mm. whilst at the head it reaches not more than .116 mm. (In another case head .075, body .175 mm.).

Like other male Nematodes the tail is curled ventrally round its spicule, which though small can just be seen with the naked eye as a white speck.

ALIMENTARY CANAL.

The alimentary canal of the male worm presents a striking contrast to that of the female and to that of the male found in the buffalo's tumour, in the possession of a very muscular and easily recognised stomach. The oesophagus is .511 mm. in length, *i.e.*, a little shorter than in the female (.584 mm.). It is suddenly expanded into a thick muscular intensely white stomach which runs a straight course and measures 2.2 to 2.5 mm. in length.

After this the alimentary canal narrows again into the intestine, which is a little bigger than the oesophagus. The intestine is continued along the length of the worm and finally ends in the cloaca.

No definite glands may be seen opening into any part of the digestive tract.

GENITAL SYSTEM.

There is only one Testis, elongated in shape and lighter in colour than the gut lying by its side. Above it reaches a variable distance, but below it is continued into the single vas deferens which finally terminates by opening into the common cloaca. At the cloaca which is situated .15 to .20 mm. from the tail extremity, one notes two spicules—an anterior and longer one (? penis) and a shorter and posterior one (? sheath). The anterior spicule, which is continuous with the vas deferens through the funnel shaped opening, measures .262 mm. in length, whilst the shorter or posterior spicule is .116 mm. long.

The general arrangement and structure of these spicules are much the same as in the corresponding worm of the buffalo and therefore need not be repeated here. To the two spicules are attached powerful muscles for their free movements.

The interesting part lies in the papillæ, of which two pairs are anterior to the cloaca (preanal) and at least six pairs are posterior.

These papillæ are much larger and more distinct than in the buffalo's worm, where only two can be faintly made out. The two preanal ones are particularly large, the first lying 18 u. anterior to and the second just in front of the cloaca.

The second and third pairs and the third and fourth are each 37 u. distant from one another, whilst the last three pairs are quite close together. They diminish in size as we go backwards.

The position and relation of these various papillæ present a more striking picture when seen from the ventral surface than when viewed

sideways. When viewed under a high power the general epithelium covering the body is seen to be thrown over these sensitive structures as a distinct well-marked line.

The groove lying between these two rows of papillæ is wide.

SPERMATOOZA.

The spermatozoa as obtained from the testis of a bullock's worm are round granular very refractile bodies, and in the fresh state cannot be easily distinguished from ova. They of course escape from the cloaca through the penis, and are often glued together in clumps and suspended from the opening.

In stained specimens they shrink up greatly and appear more or less pyramidal in shape, being attached to one another by delicate fibrinous matter, the whole picture thus assuming a grapelike form. The nuclei are deeply stained whilst the protoplasm presents no special characteristics.

The points of difference and resemblance in the two species of worms are seen in the subjoined table:—

Females.

	BUFFALO WORM.	BULLOCK WORM.
Length	Average 220 to 250 mm. ..	Over 60 mm.; never completely dissected out.
Greatest Breadth ..	1.25 to 1.5 mm.	.35 mm.
Diameter of Head ..	.29 to .30 mm.	.25 to .27 mm.
Character of cephalic end.	Tapering and much smaller than body. Tapering portion 25 mm. Neck surrounded by a collar.	Not much narrower than rest of body. No distinct line of demarcation from rest of body.
Distance of genital pore from oral opening.	.65 to .75 mm.	.90 to .95 mm.
Diameter at point of genital pore.	.33 to .37 mm.	.20 to .29 mm.
Distance of anus from tail.	2 to 3 mm.	?
Cuticular thickening at tip of tail	Not specially thickened ..	?
Mouth	Surrounded by an oral ring.	No definite oral ring detected.
Oesophagus	Narrow, retractile tube, 7 mm. long. Diameter Oesophagus .116 mm. Diameter Stomach .233 mm.	Narrow retractile tube .58 to .62 mm. long.

Females.—cont.

Stomach		Thick muscular wall. Marked bulbous expansion from œsophagus. No definite line of demarcation from intestine.	Thick muscular wall. Expansion from œsophagus. No definite line of demarcation from intestine.
Intestine		No division into rectum. Ends in anus (subterminal).	Is continued to anus. (?) subterminal).
Length of uterus		40 mm. Divides first into two tubes, each of which again subdivides into two.	10 to 15 mm. Divides into two tubes only.
Ovarian tubes		Four altogether. Bulbous and very opaque and distended.	Two only. Not bulbous or much distended.
Character of ova		Oval cells surrounded by thick capsule usually. Capsule possesses two pointed spicules at extremities, sometimes one.	Similar to that in buffalo.
Character of embryos..		Very active. Length .29 to .32 mm. Breadth at head 3.5 to 4 u.	Very active. Similar to that in buffalo.

Males.

Length	45 to 50 mm. long	42 to 45 mm. long.
Greatest Breadth	.34 mm.	.145 to .175 mm.
Diameter of Head	.32 mm.	.075 to .116 mm.
Character of Cephalic end.	Nothing marked. No differentiation from rest of body.	Nothing marked.
Distance of cloaca from tail.	.102 mm.	.210 mm. (over twice distance that in buffalo).
Cuticular thickening at tip of tail.	Not marked	Marked (over 5 times usual thickness).
Spicules	Two { Anterior long .22 mm. Posterior short .12 mm.	Two { Anterior long .262 mm. Posterior short .116 mm.
Papillæ	Two pairs preanal. Very small, posterior one being more evident; postanal doubtful.	Two pairs preanal large and distinct. At least six pairs postanal, also distinct.
Mouth	Oral ring usually in living specimen.	No oral ring detected.
Oesophagus	Narrow tube .584 mm. long.	Narrow tube .511 mm. long.
Stomach	Expanded tube	Expanded tube, very opaque 2.2 to 2.5 mm. long.
Intestine	No differentiation from stomach.	No differentiation from stomach.
Character of Spermatozoa.	Refractile bodies, smaller in size than ova. When fresh oval or spindle shaped. When stained usually pyramidal. Attached by delicate threads to one another.	Similar.

OTHER DISEASES.

Results of Post-Mortem Examinations.—The bodies were obtained from the District Hospital, Kwala Lumpur, from April 1st, 1903, to August 15th, 1904. During the period 805 Chinese and 126 Tamils and Bengalese died. Of these the bodies of 328 Chinese and 32 Tamils were examined. On account of religious and racial prejudices no autopsies can be obtained on Malays whether from Malay proper or the islands in the Malay Archipelago.

It is to be, therefore, noted that these examinations show the diseases present and the causes of death in imported races only. How far the diseases also were imported or acquired in the country is in some cases uncertain, but as most of the cases were of persons who had been resident in various parts of the Federated Malay States for some years, all the acute diseases must have been acquired in this country.

Generally speaking, only a few of the examinations made were of selected cases, but there were exceptions which will be considered separately. The causes of death were, in many instances, complicated. Dysentery in particular appears to be a terminal disease in many chronic illnesses, just as diarrhœa in children is often the last stage of any wasting disease in temperate climates.

Of the Chinese cases examined, 328 in all, 65 had Dysentery, 64 Tuberculosis, 19 Acute Malaria with parasites present, 17 Pneumonia, 5 Typhoid, in 34 probably the chief cause of death was Beri-beri. There were 17 deaths from Sepsis, 14 from Cirrhosis of the Liver, 10 from Malignant Disease, and two from uncomplicated Anchylostomiasis.

Of the 32 Tamils examined, 17 died of dysentery, 5 from Pneumonia and Anchylostomiasis respectively, and 4 from Tuberculosis.

Subjoined in tabular form is the percentage of each of the more common diseases in the two races.

Percentage of Deaths.

	CHINESE.	TAMILS.
Dysentery	22	51
Tuberculosis	19.5	12
Beri-Beri	10.3	...
Malaria	6.6	...
Pneumonia	6	15
Achylostomiasis	.6	15
Malignant Disease	3.3	...
Cirrhosis of Liver	4.6	3
Sepsis	5.6	...
Bright's Disease	3	...
Typhoid	2	...

It will be seen that there is a marked difference in the incidence of the diseases in the two races, and that whilst Tamils suffer more from Dysentery

and Pneumonia, they are here not so often victims of Beri-Beri. The Chinese suffer less from Dysentery and Pneumonia but more from Tuberculosis. A similar difference is observed amongst Negro and Indians (mainly from Calcutta) in British Guiana. Tuberculosis is the pulmonary disease of the Negro, and he rarely gets Pneumonia, whilst the Indians, the Aborigines and the Europeans are rather less subject to Tuberculosis but much more so to Pneumonia.

The prevalence of fatal Malaria amongst the Chinese is noteworthy, as the Tamils are equally exposed to infection, and are by no means exempt from mild attacks. This susceptibility to Malaria in the Chinese is probably due to the smaller amount of Malaria in China than in the Madras Presidency or Ceylon, so that the Chinese have not suffered the early and repeated infections necessary to induce immunity. Two-thirds of the fatal cases were in persons who had been in the country four years or less.

The fatality amongst Chinese when introduced into badly Malarial countries, such as West Africa, is well known, and the same occurred with Chinese imported into British Guiana. Fortunately this disease can be controlled as results here have shown, but without serious and persistent efforts to reduce the amount any natural increase in the Chinese population outside the towns cannot be anticipated.

The occurrence and causation of Malaria in these States has been already considered.

TUBERCULOSIS.

Tuberculosis is now one of the most important diseases in the country, and according to all the evidence seems to have become much more prevalent during the last few years.

As a cause of death, judging from these returns, it ranks second only to dysentery. The medical history of other tropical countries has shown that this is a usual sequence of the imperfect adoption of European methods of life. The increased cost of land results in overcrowding. The small rooms and houses built in European style are much more expensive than native houses. They can only be remuneratively leased to persons drawing \$10 to \$15 a month usual wages if overcrowded. In such houses air is usually admitted in comparatively few places and so a draught is produced.

In the tropics, particularly in sleeping persons, the skin is very susceptible to slight changes in temperature, such as those produced by a draught, so that for the sake of comfort and to ensure an equable temperature such ventilating holes are frequently stopped up by the inmates of the house and the ventilation reduced to a minimum.

The dry cement or wooden floors are rarely more than brushed and never disinfected. Expectoration is indulged in freely.

Under these circumstances Tuberculosis introduced into a house, workshop, gambling room, theatre or temple, has every chance of spreading. The increase in the towns and, at present, the inefficiency of such regulations against overcrowding, etc., as exist, suffice to explain the large percentage of Tuberculosis now present, and to give serious grounds for fear that this disease will assume more serious proportions and affect the other races here resident who now suffer to a smaller extent.

In the great majority of the cases the disease has been acquired in the Federated Malay States. Of 37 in which the length of residence is recorded,

in none had the patients been less than 2 years in this country. In 9 they had been from 3 to 5 years, in 11 from 6 to 10, and in 10 over 10 years.

The increase of Tuberculosis in other tropical countries is important in this connection.

There is evidence that Tuberculosis was very rare in Demerara in the early part of last century. In 1842 BLAIR states that cases were more numerous than usual, but that of the 17 cases in the Georgetown Hospital not one was a native of the colony.

From 1842 to 1848 there were 86 deaths from Phthisis out of 2,268, or 3.7 per cent.

Now between 25 and 30 per cent. of the deaths, and a larger proportion if infantile deaths are excluded, are from Tuberculosis, and the proportion amongst the natives is as high as in imported races.

Distribution.—Evidence of tubercle was present in 70 cases. In some it was either cured or in an early stage and not sufficiently extensive to be the cause of death. In 5 there were calcareous nodules at one or both apices with much puckering of the apical portion of the lobe and some increased fibrosis. In two more there were similar calcareous or cretaceous nodules with surrounding recent miliary tubercle, and in one of these there were also tubercular ulcers in the small intestine. This tendency to cure in cases of Tuberculosis in the Chinese is promising. It is in marked contrast to the absence of any such tendency in Negroes and in most primitive races. In four a small portion of the superior lobe on one side only was involved, and in one of these there was a small recent cavity. In the remaining 60 cases Tuberculosis was advanced. Both lungs were involved in 49; one lung only in 21; so that in all the lungs were involved. In addition in 3 the larynx was extensively involved; in one the tonsils; the stomach in 2; the small intestines in 40; and the large intestine also in 21. When the large intestine was involved, superficial or deep non-tubercular ulceration was often present as well. In some cases where there were no tubercular ulcers, ulcers of other nature were present.

This extensive implication of the large intestines in cases of tubercle is one of the features of tropical tuberculosis. It is to be noted that in one case it was associated with almost healed pulmonary tuberculosis, and that in extent it is not related to the amount of pulmonary tuberculosis, that it is not usually associated with tuberculosis of the mesenteric glands and with a general tuberculosis though they may be present together. The probable source of the intestinal tuberculosis is auto-infection by swallowing sputum. The absence of tuberculosis from cattle renders it improbable that here it is derived from external sources.

General tuberculosis involving several organs of the body was fairly common. In 16 the spleen was involved, in 7 the liver, and in 6 the kidneys. In some of the instances no visible tubercles could be seen, but scrapings showed the presence of tubercle bacilli. In 5 there was tubercular peritonitis, and in one other case extensive old peritoneal adhesions. There were two cases of Tubercular Meningitis, and one of a tubercular mass in the brain.

Of associated diseases which probably had no connection there were two cases in which death was due to Cerebral Hæmorrhage, one in which it was certainly due to Beri-beri, one advanced Cirrhosis of the Liver, and one Dysentery and Hepatic Abscess. Of other associated diseases, in view of the recurrence of the often disproved statements of an antagonism between tuberculosis and malaria, it may be noted that parasites of Malaria were found in one case of healed Phthisis, in one of early pulmonary tuberculosis, and in two of fairly advanced tuberculosis. In several other cases recent Malaria pigment was present in the organs.

As regards occupation, such a large proportion of the persons who attend the hospital are or have been mining coolies, that these naturally form the large proportion of the patients with tuberculosis. Other occupations represented were ricksha pullers, shopkeepers, mechanics, and rarely domestic servants.

In two cases there was marked Anthracosis probably from charcoal burning.

Age.—Of 65 in which it could be approximately obtained there were 35 of 25 years of age or under, and 30 over 35 and 15 of these were over 50. As half the deaths are under 35 the incidences of this disease in old age is rather heavier than in temperate climates for advancing years, but not more so than is usual in the Tropics.

In the lower animals in the state of nature Tuberculosis is apparently unknown here. In confinement monkeys, even in well ventilated houses and when kept clean, frequently acquire it. In all cases seen the lungs were affected either alone or more commonly associated with general tuberculosis, but showing the oldest lesions in the lungs. In one case there was a definite tubercular nodule in the substance of the brain.

No tubercles were found either in imported or native cattle slaughtered or dying from Rinderpest and I am informed by the Government Veterinary Surgeon that he has not seen any cases. This is in marked contrast to British Guiana, where of animals slaughtered for food a considerable proportion are tubercular.

With the increase in Tuberculosis in man the development and spread of this disease amongst the cattle may be anticipated, as recent evidence is all in favour of the occasional communicability of Tuberculosis from man to cattle and *vice versa*.

DYSENTERY.

Dysentery is the direct cause of over 40 per cent. of the deaths in the hospital, and is a contributory cause of death in a considerably larger proportion of cases.

In Tuberculosis with or without tubercular disease of the intestine it is not uncommon, and superficial ulceration, hardly to be called true dysentery, is present in many of the chronic diseases.

Of the various types of dysentery the most clearly separated is the so-called Amœbic Dysentery when it occurs uncomplicated. Unfortunately mixed cases or cases not corresponding to the type in which Amœbæ are invariably found are not uncommon. The lesions which may be considered

as typical and in which the Amœbæ are always to be found are limited to the large intestine which is usually involved in its whole extent but with more advanced or extensive lesions in the cæcum and sometimes in the sigmoid flexure.

The general mucous membrane is little affected, but the ulcers are deep and have a yellow adherent slough attached and a surrounding intensely injected edge. The ulcers in the transverse colon are discrete and vary in size from little more than a pin point to one inch in diameter, and are usually in various stages. In the cæcum and sigmoid flexure several of these ulcers often coalesce, so that in these parts a large shaggy adherent sloughy surface is presented. The pus from these ulcers or sloughs is distinctly mucoid. The amœbæ are found in this pus and in the sloughs, but most abundantly in scrapings from the floor of the abscess.

Mixed cases occur in which the intervening mucous membrane is also ulcerated or intensely congested. Tubercular ulcers in cases of tuberculosis may also be met with in conjunction with this Amœbic form of dysentery.

In other cases in which Amœbæ may or may not be found scars of old ulcers, healing ulcers and submucous abscesses in which the mucosa is undermined and more or less extensive collections of pus communicating with the lumen of the intestine by a mere pin point occur. This pus usually, but by no means invariably, is free from Amœbæ. *Balantidium coli* is sometimes met with in pus from such situations.

Hepatic abscesses were found in 1 per cent. of the Chinese examined. This proportion is about the same as in British Guiana. In each case ulceration of the colon, usually markedly of the Amœbic type, was present, and in all cases Amœbæ were found both in the liver abscess and in the intestinal ulcers or their discharges.

Another marked type of dysentery is the so-called diphtheritic form. In the pure cases of this type the disease is not limited to the large intestine but a variable length of the ileum and rarely also of the jejunum is involved.

The lesions in the small intestine may simply be extreme congestion most marked at the summits of the rugæ. More commonly in the lower part of the ileum there is a granular adherent superficial slough firmly adherent to the summits of the rugæ. This condition may extend up to the jejunum, but is always most marked in the last few inches of the ileum where the superficial slough may completely cover the mucous membrane. Peyer's patches and the solitary glands are not swollen or specially involved.

In the cæcum the congestion is intense, the slough is deeper, and on forcible removal leaves an ulcerated surface. The whole extent of the large intestine is usually involved, but towards the rectum at the time of death there may be ulceration and little of the sloughs are left. Nine of the cases were of this type uncomplicated by other lesions.

In a typical case with these lesions Amœbæ are not found, and in most of the mixed cases in which this form of dysentery can still be recognised Amœbæ are absent, but the two types Amœbic and Diphtheritic are occasionally present together.

It is strictly speaking an Entero-Colitis, and though the lesions in the majority of cases are most marked in the cæcum and large intestines in occasional rare cases the main seat of disease is in the lower part of the ileum.

A large proportion of cases of dysentery cannot be assigned to any definite type. Ulcers irregular in size, in depth, in character of surface or edges may be scattered thickly or sparsely over a varying extent of the large intestine. In such cases the actual ulceration and secondary ulcerations appear to disguise the type.

Tubercular ulcers and typhoid ulceration of the large intestine are commoner relatively in the tropics than in temperate climates, but present no difficulty in diagnosis and should cause no confusion.

The *Amœbæ Coli* has, in my opinion, a strong position as the factor in a large class of dysenteric lesions. The *Balantidium Coli* may play a part in the causation of certain other forms. In the remainder in the majority of cases no animal parasites are to be found. The bacteriology of the large intestine and its contents naturally has attracted much attention. The number of organisms found either in the contents of the intestines on scraping the ulcers or in the sloughs is large, and many of them are either commonly or rarely found in normal intestines but are present both more constantly and in larger numbers in cases of dysentery.

Amongst these organisms *B. pyocyaneus* is perhaps the most important. It is not a very rare bacillus in normal stools but appears to be present in the majority of cases of dysentery examined here. It is found not only in the contents of the intestines and in the sloughs, but in the depths of the ulcers and in the deep scrapings of the mucous membrane occasionally in the mesenteric glands and rarely in the spleen.

This organism has been credited with the causation of certain epidemics of dysentery. (HEWLETT'S *Manual of Bacteriology*, p. 439.) The varying lesions found associated with this organism, and the absence of any lesion or symptom of disease in other cases where the organism is present, render it improbable that it is the cause of the disease, but the increased numbers and the known pathogenicity of the organism in lower animals and its occurrence in tissues are arguments for considering it of importance as a secondary cause of some of the lesions or complications. The organism isolated from dysentery cases is indistinguishable from that isolated from healthy intestines or from natural sources, and does not appear to be more rapidly fatal when injected into rats or guinea-pigs.

This organism is of particular importance as it occurs in nature. It is also capable of conveyance by mosquitoes of certain species. The larvæ of many species of mosquitoes breed freely in more or less diluted fæces even in cess pits. Amongst these *Culex fatigans*, *Stegomyia fasciata* and *Stegomyia scutellaris* and sometimes *Anopheles Rossii* may be mentioned. A minute addition of sewage is fatal to few larvæ.

Under these circumstances as the larvæ contain in their intestines some of the organisms present in the water in which they live, it is not a matter of indifference to determine which of these organisms can be found in the adults and passed or conveyed by them.

Experiments (*vide note*) showed that *Pyocyaneus* can be conveyed in this manner by certain species of mosquitoes, and that the adults may therefore carry this organism to any substance on which they may alight, die

or deposit their dejecta. The reduction of the number of mosquitoes even of apparently harmless species is, therefore, of considerable importance.

Organisms corresponding to Shiga and Flexner's *B. dysentericus* were isolated in many cases of dysentery from the intestinal contents, the ulcers and the scrapings from these ulcers. They were not found in the spleen or lymphatic glands even when enlarged, or in the Hepatic abscesses.

Dysentery is of rare occurrence in Europeans residing in the larger centres, but is common amongst those who do much travelling. Amongst natives resident in the towns it is fairly common, but more so in the small mines and in the bush. Gaol dysentery does not occur here, but in Singapore gaol epidemics of severe type of dysentery do occur. It occurs at all ages, but proportionally is more common from 25 to 35 than at other decades.

The water supply to European houses in Kwala Lumpur is from the Ampang Reservoir entirely. To the native quarters it is in part only from this source, more often from surface wells or even holes in the ground or from polluted rivers and streams. Milk is often mixed with water from such sources.

With dysentery there is not the same certainty that it is only derived from previous cases as in typhoid. On the contrary the evidence of travellers through uninhabited tracts of country strongly supports the wide spread belief that jungle streams are a fruitful source of the disease. This question will be further considered in dealing with the bacteriology of natural water supplies.

Dysentery was the cause of 17 or rather more than half the cases examined amongst the Tamils. The same types of Dysentery were found. In two cases there were Hepatic abscesses.

This greater liability to deaths from Dysentery on the part of the Tamils is, I believe, racial, but it must also be remembered that the Tamils are more careless as to the water they drink and the disposal of fæces.

NOTE.—Experiments were made by placing various larvæ in water to which cultures of various organisms were added and allowing them to develop in such water. Other food material and other organisms were present in the water but the persistence of those added was determined from time to time by plating. *B. pyocyaneus*, *B. prodigiosus*, *B. violaceus*, *Sarcina lutea* and *B. subtilis* were the organisms used. Shortly before pupation the larvæ were transferred to sterile water and after pupation changed frequently to different tubes of sterile water to remove as far as possible adherent organisms.

The mosquitoes as soon as possible after hatching were transferred to slope agar tubes and retransferred to other sterile tubes either dry or containing agar agar, and finally were allowed to die on sterile broth or were dissected on agar plates and these were then incubated.

The larvæ experimented with were those of *Culex fatigans*, *Stegomyia scutellaris* and *fasciata* and *Anopheles Rossii*. The results obtained differed with each species of mosquito. *Stegomyia fasciata* in every instance was found to carry *B. pyocyaneus*, some of the tubes giving pure cultures of that organism. In none of the other mosquitoes used was this organism found. *B. violaceus* was found in none of the tubes used by the mosquitoes, *B. prodigiosus* only exceptionally, and *B. subtilis* in about $\frac{1}{4}$ of the tubes. *Sarcina lutea* was carried by *Culex fatigans* in a few instances only. Moulds of various kinds were common with all, but most abundant with *Stegomyia scutellaris*.

Mosquitoes caught in various districts were examined in a similar manner. A few specimens *Stegomyia fasciata* were found with *B. pyocyaneus*, and one specimen of *Wyeomyia splendens*, a pure bamboo breeder, also harboured this organism. In a few specimens of *Culex fatigans*, *Anopheles Rossii* and *Desvoidia fuscus* an organism resembling *B. Coli* but not coagulating milk was found. This organism appears to be closely related to the water organisms of this class so common in Malaya. Experiments with *B. typhosus* failed in every instance. Organisms, therefore, may be acquired as larvæ from sewage or other sources and conveyed by the adult mosquitoes to water, fruit, sugar or any other substance.

BERI-BERI.

Beri-Beri still continues directly or indirectly to be the cause of a considerable proportion of the total mortality. It is no longer epidemic or endemic in the gaol or other public institutions, so that the observations which are most needed, those on the onset of the disease, have been impossible.

The rapidly fatal cases are now exceptional in the hospitals, and where a history was obtainable one-third of the patients had been ill for three months or more, nearly all the others for over one month. The shortest histories were of 10, 12, 19 and 20 days respectively, and these were not reliable.

The duration of the Acute or prodromal Beri-Beri described by Dr. HAMILTON WRIGHT was therefore passed in these cases, and I am, therefore, not in a position to confirm or develop his observations on the pathological changes in that period.

The patients, 838 in the past 12 months, were mainly from the surrounding mining districts, but 76 were from the town itself. These may have been late relapses, but in the gaol there have been in the past 18 months four cases with no previous history of Beri-Beri who developed the disease more than two months after admission to gaol. It appears, therefore, that the source of infection is still present in the gaol and probably in the town also.

The history of the outbreaks of Beri-Beri at the Pudooh Goal have been the subject of many careful enquiries and much investigation. The first Director of this Institute, Dr. HAMILTON WRIGHT, in Studies No. 2, published full statistics up to May 1st, 1903. Dr. H. E. DURHAM in slightly different form also published statistics "*Journal of Hygiene*," January, 1904. Detailed statistics up to a later date have been published by the State Surgeon, Selangor, E. A. O. TRAVERS, M.R.C.S., "*Journal of Tropical Medicine*," September 15, 1904, as well as previous accounts of the earlier outbreaks.

In continuation of the statistics published in Studies No. 2 the following figures are of interest as showing the decline of the outbreak there described. I have excluded cases in which the patient was suffering from the disease on admission and those which were observed in prisoners awaiting trial. In the fourth column only cases are included in which no previous history of Beri-Beri could be obtained. The frequency of relapses even after considerable periods and with apparently no probability of re-infection renders this subdivision necessary, but it must be admitted that these relapses are more frequent when fresh cases are occurring, and it is noteworthy that though the diminution in the number of relapses was less rapid than that of fresh cases, still, during the period of 7 months when no fresh cases occurred, there were no relapses. Many of the relapses are probably re-infections so that the third column under-estimates the real number of fresh infections.

The figures show a rapid decline in the number of fresh cases towards the end of 1902, followed by a cessation of fresh cases for a period of 7 months, and since then in the last 13 months occasional cases have occurred but no epidemic. During this time there was one period of 4 months and one of 2 months in which only relapsed cases occurred. During the whole period there were 22 cases commencing in the gaol and of these 8 had no previous history of the disease, some of the others were certainly

relapses with histories of frequent relapses. The remainder may or may not have been re-infections. Amongst the population from which the prisoners are drawn in Selangor, from about 3 cases per 1,000 to some 100 or more per 1,000 are the proportions per annum.

1902.	Rainfall.	Total Cases.	Deaths.	1st. Attacks only.	
May	12.13	90	6	64	S.W. Monsoon.
June	4.33	83	5	49	
July	3.83	67	7	38	
August	5.11	76	2	26	Sept. 23rd. Extramural work. Meals, except evening one, outside cells.
Sept.	8.74	131	7	28	} Oct. 20th. Kanji cooked at 3.30 a.m. and served out hot 5.30 a.m.
October	22.29	99	5	32	
Nov.	16.44	35	2	4	
Dec.	13.83	55	3	11	
1903.					N.E. Monsoon.
January	6.22	22	1	6	} Greatly improved ventilation of cells.
Feb.	5.44	—	—	—	
March	10.50	—	—	—	
April	7.62	—	—	—	
May	13.50	—	—	—	
June	5.44	—	—	—	S.W. Monsoon.
July	4.31	—	—	—	
August	6.45	—	—	—	
Sept.	4.46	1	..	1	} N.E. Monsoon.
October	9.89	1	1	1	
Nov.	5.63	1	..	..	
Dec.	15.39	..	..	..	
1904.					Extra-mural work stopped Jan. 22. Meals taken in cells.
January	12.92	..	..	..	March 9th. Extensive excavations for foundation of stonebreaking cells. S. S. prisoners only.
Feb.	5.34	2	..	..	} April 9th. Meals taken outside cells.
March	4.55	5	..	3	
April	12.24	1	..	..	
May	8.47	..	..	..	

1904.	Rainfall.	Total Cases.	Deaths.	1st. Attacks only.	
June	3.80	2	..	1	S.W. Monsoon.
July	7.88	6	..	3	
August	4.10	2	..	..	
Sept.	..	1	..	..	N.E. Monsoon.

The exclusion of cases admitted with the disease is made as the gaol conditions cannot be held responsible. Prisoners awaiting trial have not the same medical examination and are under different conditions so these also are excluded. In the tables published by TRAVERS these classes of cases are included.

The average gaol strength is about 500, so that the incidence of the disease was not extraordinarily heavy.

There is also reason to believe that some of these cases were infected previous to their term of imprisonment. Of the 8 fresh cases one developed the disease within a week of admission and 3 under 2 months. Some at least of these may have been infected before admission. Of the other four cases one had been 7 months in gaol, 2 10 months and one a year. These, I consider, prove that the source of infection still exists, or is, from time to time, introduced amongst the prisoners, and that the conditions necessary for the spread of the disease still exist to a minor extent. Between November 1st, 1903, and September 30th, 1904, there were 9 cases admitted with the disease not included in the above lists. Three of these were admitted in November. No prisoners were admitted into the gaol in the previous 8 months with the disease. The cases occurring in the gaol before this date were both under two months after admission. The first cases which occurred (3), 7 months or more after imprisonment were in the following March, and in that month also two persons were admitted with the disease.

It has, I consider, been proved that the period of incubation of the disease is variable, and also that it may be short, but it has not been proved that it may not be as long as two months or even longer. It would appear probable that the source of the outbreak is to be found in the admission of prisoners in the incubation period and its continuance to the introduction by them of the disease into the gaol.

A similar sequence of events occurred in the Singapore gaol at the commencement of the outbreak there in September, 1903. There had been no fresh cases for over 3 months, but one occurred in September in a prisoner 5 weeks after admission. In October there were two cases in short sentence prisoners, but one of these had been over 3 months in gaol. In November there were 32, including 6 who had been over a year in the gaol, and in December the epidemic reached its maximum of 41 cases, including 5 who had been in gaol over a year.

The incidence of the disease in the first 5 months of the epidemic was heaviest amongst the short sentence prisoners, 64 cases, and amongst the lower grade prisoners in the first year 13. The average strength of these

classes was 368, so that they were affected in this period at the rate of 209 per 1,000 or 501·6 per annum.

In the middle grade, prisoners who had been over a year in gaol, 13 were attacked in the last 2 months of the same period. The average strength of this grade is 284, so that the incidence was at the rate of 45 per 1,000, or 270 per annum per mille.

The upper grade prisoners escaped the infection. Two cases which occurred amongst them had only just been transferred from the middle grade.

A reduction in the diet of the short sentence and lower grade prisoners was made on October 1st at the Singapore Gaol after the occurrence of the first case, but the change did not affect the middle grade prisoners who were also attacked.

At the Pudu Gaol no changes were made in the diet during the whole period. The food was procured in the same manner from the same contractors, and no alteration was made in the method of cooking with one exception, and that was that from October 20th the morning rice, *kangi*, was cooked at 3.30 a.m., and kept hot till served out at 5.30 a.m., instead of as before being cooked at 5 p.m., and not prevented from cooling before being served out in the morning.

In the distribution of the food a change also was made, as all meals but the evening one, at 5 p.m., were served and eaten in the corridors instead of in the cells.

Another important change was effected in that confinement in cells was considerably reduced, and as much as possible the prisoners were employed in extra-mural work in open sheds from September 23rd, 1902. Early in 1903 the cell ventilation was greatly improved but was not completed till May. A few cells, as an experiment, were altered between November, 1902, and January, 1903.

It is difficult to believe that the cessation of the outbreak and the important changes effected in September and October are mere coincidences. The long spell during which the gaol was free from the disease exceeds any of the previous but shorter periods which have occurred, and the present position of affairs is not unlike the condition in 1898 when there were from January to September inclusive 42 cases with one death only.

Dr. TRAVERS informs me that during this period the prisoners were kept at extra-mural work. 192 cases with 34 deaths occurred during the previous seven months from June to December inclusive. During that time the prisoners were working inside the gaol.

It can be claimed as a result of the careful attention paid to details of sanitation by the State Surgeon, Dr. HAMILTON WRIGHT, Dr. DURHAM and others, aided by the active and cordial assistance of the gaol officials and the support of the Government, that the gaol is as free from sanitary defects as possible, and that the condition of health of the prisoners is the highly satisfactory result of such attention.

The actual total mortality for the gaol in 1903 was 8 only, or 16 per 1,000 as compared with a general mortality of over 30 per 1,000, and a town mortality, including institutions, of rarely less than 60. The Indian prison mortality, 24.85, is 6.6 less than the general mortality. As in India the general mortality includes a far larger number of children than in this country a greater difference would be expected there than here. Our results therefore when compared with India are even more satisfactory than

is shown by the figures. The mortality for the first 9 months of 1904, exclusive of executions, was 8, or 21.3 per 1,000. Of those 16 deaths, 5 were of prisoners admitted to gaol with Tuberculosis. Two were from Beri-Beri.

The diminution in the amount of Beri-Beri and the cessation of the epidemic in the Kwala Lumpur Gaol does not lend any support to the purely dietetic theories of the causation of the disease. The course of both the slight recrudescence at Kwala Lumpur and the epidemic in Singapore Gaol are indicative of human agency as a factor in the transmission of the disease.

The monthly rainfall is given in the table in a separate column for comparison. There is no evidence of any relation between this and the epidemic, but as the prisoners are protected from the rain the conditions are not comparable with those in mines.

An important point in connection with the recrudescence of the disease in the Pudu Gaol is the unusually mild character of some of the attacks during the period under review. There was one death in all out of the 31 cases, *i.e.*, 22 cases originating in the gaol and the 9 admitted with the disease. This fatal case was a severe one, fatal in 24 days after the onset. Two are still in hospital.

Out of the remaining 19 patients who developed the disease in the gaol 5 were a week or less in hospital, 5 two weeks or less, and 5 a month or less.

The prisoners are discharged as fit for work, though for a few days they are kept under observation at light work. The medical officers attending the prisoners and the prison officials are very familiar with the course of the disease and the peculiar risks, and consequently this short detention in hospital is certain proof of the mildness of the attacks.

OUTSIDE THE PUBLIC INSTITUTIONS.

The disease is widely distributed and occurs not only in mines but in towns and villages to a variable extent. Exact information as to the rate is not available as the number of cases admitted to a district hospital does not represent the full number of cases that occur, as some particularly mild cases are not taken to hospital and others are taken to hospitals in other districts.

Taking hospital statistics as the only basis and realising that such calculations are only approximate and below the true figures we find that in Kwala Lumpur itself there were, amongst the labouring male population, 76 cases, or about 3 per 1,000 in the year. No figures can be obtained for the women. Several cases are known to have occurred amongst the inmates of the crowded brothels. In the adjoining mining districts of Ampang and Pudu there were respectively 149 and 64 cases, or about 13.8 and 11 per 1,000. In the mining districts round Kuala Kubu in 1903 there were from the old established mines of Rasa 18.6 per 1,000 and Rawang 29.3 per 1,000, whilst the outlying districts with small mines Kepong, Pretah, etc., the rate was 65 to 120 per 1,000 per annum.

DR. WATSON informs me that in the coast district under his charge a considerable number of cases come from the only tin mine in the district, and that isolated cases occur from time to time not only in persons on the coast who have never been inland but occasionally in persons working in lighthouses, launches, etc.

It is clear, therefore, that though a disease which is more readily acquired in crowded mining districts it occurs also in overcrowded towns and houses and occasionally under other conditions.

RACE.

There is a tendency to attach too much importance to the question of race in considering this disease, because in the Malay States the Chinese suffer most severely, and cases amongst Tamils, Malays and other races are rare. Wider experience has shown that under some conditions Europeans, Negroes and Indians are all highly susceptible, and that, therefore, the condition that leads to the more serious implication of the Chinese cannot be one of race directly. It is to race customs and habits or modes of life that difference in incidence in different races must be attributed.

OCCUPATION.

The enormous majority of the imported Chinese are or have been employed in the mines. The greatest number of cases of Beri-Beri are among those now employed on the mines, but cases occur amongst those otherwise employed. Out of 76 cases which occurred in Kwala Lumpur and 237 in neighbouring villages, 313 in all, 192 were miners and 50 were coolies. The remaining 61 were engaged in miscellaneous employments. Engaged in open air employment were 7 gardeners, 5 ricksha pullers, 3 woodcutters and 1 hawkker. The licensed ricksha men number 2,499, but as there are only 1,811 licensed ricksha and few private ones the probable number working at one time is about 2,000, so that the incidence of the disease is about 2.5 per 1,000, much less than in the healthiest mines or in the gaol, though the quarters occupied by the ricksha pullers are as overcrowded as most crowded mines and much dirtier. Even the approximate numbers engaged in other pursuits cannot be obtained.

Cases also occurred amongst those engaged in work under shelter, these included 4 cake sellers, 3 carpenters, 2 tailors 2 shoemakers, 2 barbers, etc.

At most of the larger mines at one time or other the disease has been severe and even now there is not a mining district where cases do not occur.

Amongst the agricultural population on the rubber estates or sugar estates Beri-Beri only exceptionally occurs. The Chinese and other coolies employed on the roads and works in connection with the Gombak electric power station were not attacked. In these works Malaria and Dysentery were very common, and the conditions of life on the whole worse than in a mine. They were also engaged in turning up new earth and cleaning new jungle, both classes of work popularly believed to be direct causes of outbreaks of Beri-Beri, and although these facts appear to indicate that the occupation of mining is an important factor in the causation of the disease, yet the high rate in the gaol for many years, ship epidemics, etc., show that this is not an essential.

CASE MORTALITY.

This is variable in an indefinite manner. In the gaols where a case can hardly be overlooked and errors of diagnosis have been carefully

warded against the mortality has varied since in 1895 as shown in the table:—

—	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.
Cases	158	478	275	73	73	180	205	891	29	19
Deaths	34	42	54	2	7	7	5	55	2	...
Case Mortality ...	21.5	8.75	19.5	2.75	9.5	3.9	2.5	6.25	7.1	...

In hospitals many patients are admitted moribund and histories are difficult to obtain and unreliable, errors are necessarily more frequent. In many cases the patient is suffering from two or more serious diseases so that a large personal equation enters into determination of the cause of death.

It can, however, be definitely stated that in some districts the case mortality is constantly high and in others consistently low.

In the district hospital returns Kwala Lumpur the mortality amongst those from the town and immediate neighbourhood was 53 or 16.9 per cent.

In those examined after death nearly one half were found to be suffering from other serious disease, particularly from Dysentery, and, therefore, the figures from that district give too high a rate for uncomplicated Beri-Beri.

Three districts may be fairly contrasted to show the variation in case mortality in different places. It will be noted that the case mortality has no definite relation to the number of admissions:—

—	First half year 1903.				First half year 1904.				Percentage of Total Admission.	Number of Cases of B.B. per mille of mining population.
	Rainfall.	Cases.	Deaths.	Case Mortality.	Rainfall.	Cases.	Death.	Case Mortality.		
Kajang	27.38	103	...	...	32.88	120	3	2.5	33	29.5
Kwala Kubu	55.98	69	19	28.8	62.60	131	44	33.5	12	31.
Rawang	52.79	64	5	7.8	53.59	137	14	10.2	28	29.3

The first of these districts is largely an agricultural one, but out of the last 144 cases, 139 were miners, 3 had no occupation, and only 2 were gardeners, though the miners alone would employ over 500 gardeners. So that here also the incidence is mainly on the miners. In the two largest mining areas in this district Kajang and Semenyih the rates were 24 and

35 per 1,000 miners respectively. The other two districts are two mining districts with few people engaged in agricultural pursuits. The figures for the first half year 1903 were quoted by DURHAM for the first half year of 1903 the relative mortalities are comparable. The substantial correctness of diagnosis in the period was verified in each case.

Exclusive of Beri-Beri the ratios for Dysentery and Diarrhœa were practically the same in the three hospitals, and also for respiratory diseases, so that the variation in the proportion of Beri-Beri or in the case mortality is not due to differences in the popularity of the different hospitals.

There has been a steady diminution in the case mortality as well as in the number of cases in Selangor for some years. In 1895 3,781 cases were treated with a mortality of 18.7 per cent., in 1902 2,673 cases were treated with a death-rate of 12.15 per cent. The mining population in 1897 was 47,000, and Mr. DYKES, the Senior Warden of Mines, informs me that it was probably about 40,000 in 1895, in 1902 it was 70,000, so that the proportion attacked is little more than a third of what it was.

Post-mortem examinations were made in 34 cases.

Of the gross pathological lesions the most important and most constant was cardiac dilatation. As a rule both sides of the heart were dilated and rigor mortis of the cardiac muscle either absent or poorly marked. This dilatation is associated with a certain degree of hypertrophy, as the average cardiac weight was 315.81 grammes (normal 260, the average in Chinese suffering from chronic disease such as dysentery which puts no extra work on the heart, 161.26). In some cases this dilatation was extreme and in almost every case was marked and unmistakeable. More variable was the amount of effusion into serous cavities, the Pericardium, Pleura and Peritoneum in the order named were those most frequently involved. In some cases, especially those in which the subcutaneous œdema was excessive, there was effusion into all the serous cavities.

Cultures made from these fluids in all cases where it was possible soon after death were negative, and so were those from the cerebrospinal fluid.

The œdema is not limited to the subcutaneous tissues, the submucous, such as that of the intestine, gall bladder, etc., was frequently involved.

The lungs in cases of excessive effusion showed of pulmonary collapse areas at the bases. In the great majority of the cases the lungs were œdematous.

The central and peripheral nerve lesions are fully described in the second part of Studies No. 2, by Dr. HAMILTON WRIGHT.

The early lesions according to Dr. HAMILTON WRIGHT and Dr. DURHAM are in the alimentary tract. According to Dr. DURHAM some congestion of the fauces is common, and organisms with peculiar characters were obtained in some cases. The occurrence of these organisms probably owing to the scarcity of early cases neither Dr. TUCK nor myself have been able to confirm, though the congested condition described was sometimes seen. Dr. HAMILTON WRIGHT laid great stress on the condition of the stomach and duodenum, and on the congestion in some cases of extensive areas of the intestines in early cases or in cases with acute exacerbations. This congestion is certainly common and was present in 13 of these fatal cases, and in two others the duodenum was markedly congested though the stomach was not. In two others there was marked congestion of large intestine though none of the stomach or small intestine. In four of the cases in which there was marked congestion the examination was made

within three hours of death, and in two of these within two hours, so that no question of post-mortem changes can be entertained. Though these changes appear to be common sufficiently so to form an important point in connection with the post-mortem diagnosis of the disease it does not appear to be certain that they are not in themselves secondary. Similar congestive changes occur in rabies and in other diseases affecting the nervous system.

Cultures from the contents of the viscera and from scrapings of the congested areas revealed no characteristic organisms, and those from the subjacent mucosa, from the glands, spleen, etc., were usually negative or showed organisms such as coli which enter the tissues from the intestine soon after death.

Marked and sometimes extreme dilatation of the stomach was a common factor and occurred both in congested stomachs and in those in which there was no trace of congestion. The stomach sometimes contained food showing so little signs of digestion that death must have occurred very shortly after the food was taken. Considering the cardiac condition it is possible that a more restricted or less bulky diet than rice is advisable in such cases.

In other cases the stomach contents were mainly fluid or contained food in an advanced condition of digestion.

The difficulty in deciding as to the real cause of death in some cases is great. Absence of patella reflex is not sufficient here to be diagnostic of the disease in an acute form. Many of the patients die almost immediately after admission and no history is obtainable. In such cases although no patella reflex was obtained if, for example, advanced tuberculosis, severe acute dysentery, peritonitis or advanced malignant disease is found at the autopsy even if Beri-Beri was concurrent the cause of death is not fairly to be attributed to that disease.

On the other hand a patient in the poor condition of health induced by chronic Beri-Beri, post Beri-Beric Neuritis, is liable to intercurrent diseases which frequently terminate fatally, and in these Beri-Beri is the primary cause of death.

The complications in the cases I have included in my list are as follows:—Dysentery, five cases in patients who had Beri-Beri for 1 to 11 months. Pneumonia, 1 case in an old Beri-Beri patient whose last relapse was five weeks before death.

Septicæmia, three cases. This is a sequela that is a fairly common cause of death. These cases were two of extensive sloughing bedsores, in one of which infarcts were found in the spleen, and a third with both buttocks gangrenous.

In these cases death was due to complications rather than to the disease itself.

Two of the patients had old tubercle, but neither extensive nor generalised. Two had cirrhosis of the liver. Two had renal calculus.

In nearly one-third of the deaths regarded as due to dysentery the initial diagnosis on admission was of Beri-Beri on the ground mainly of the absence of Patella reflex. Whether or not the patients had also Beri-Beri in an acute form may be doubted, but the post-mortem lesions of dysentery were severe enough in themselves to have been alone the cause of death, and I have, therefore, included them in the returns for dysentery, not in those of Beri-Beri. In this connection it must be remembered that a form of paraplegia following an attack of dysentery is not unfrequently met with in

countries free from Beri-Beri, and that this paralysis is also associated with loss of patella reflex.

Of 34 cases of Beri-Beri in which age was determined, 6 were 25 and under, 24, 40 and under, and only 4 over 40.

In conclusion. There is nothing in the above to show that a poor diet is a necessary factor. The food in the gaol as far as can be ascertained has been of the same quality as in 1901 and 1902. It appears to be of good quality and to contain a sufficiency of essentials. The prisoners appear to be well fed and in good condition. In the mines the food is abundant and of great variety. The miners can and do supplement the food supplied with various additional articles of diet. The wages earned are high, the work is not excessive, and the men appear to be in excellent condition. Great attention is paid to the cooking in the mines and it appears to be thorough. The food is well cooked in the gaol. The change made in not allowing the morning cooked rice to stand overnight is one of the possible causes of the diminution of Beri-Beri, but in spite of this change cases have certainly originated in the gaol since, and in a proportion as great as amongst the general population, and greater than in Kwala Lumpur itself.

The theory advanced and supported by Dr. HAMILTON WRIGHT that Beri-Beri is communicated *via* the excreta from man to man receives some support from the course of the recrudescences of the disease in the Singapore Gaol and in the Pudu one, in as far as it supports the view that man himself is the carrier. Opportunities of contamination of food, etc., by the excreta are numerous in the Singapore Gaol, and the prevalence of dysentery in that gaol supports the belief that it does occur.

Opportunities also occur in the Pudu Gaol as the excreta are passed in the cells during 14 hours out of each 24, and though now the chances of contamination of the food are reduced by the food being served outside the cells, this does not entirely prevent chances of contamination. A proof that it does occur is that one fatal case of Typhoid developed after 4 months imprisonment in 1903, and in the same year one fatal case of Diarrhoea also after 4 months.

In 1904 up to September there had been two fatal cases of dysentery, one in a prisoner who had been over 4 years in the gaol.

The water supplied direct from the town service reservoir is boiled before use for drinking purposes in the gaol, so that it is improbable that either these cases of intestinal disease or of Beri-Beri were carried by the water.

The smaller amount of Beri-Beri in old established mines and in towns overcrowded for years such as Kwala Lumpur, as compared to new mines or to the same places a few years ago, does not support the view of ground or place infection.

ENTERIC FEVER.

Typhoid Fever presents the same symptoms as in England though the temperature is not so high and is more irregular. In one case out of the five the solitary glands of the large intestine were implicated but not to so large an extent as sometimes occurs in British Guiana. In two of the cases death was due to perforation and peritonitis. Cases are not uncommon amongst Europeans living in Kwala Lumpur as well as

elsewhere. In all probability the only method in which Typhoid infection occurs here amongst Europeans is from water. The main water supply of the town is drawn from an area free from human habitation and rigidly reserved. Faecal contamination with Typhoid dejecta is almost impossible. The town service reservoir is on an isolated hill, has no houses above it, is well covered in, and free from any possible source of contamination. There is no reason to suspect contamination of the water during delivery. Unfortunately considerable areas in and close to the town are not supplied by this water and the water used is derived from wells and pits in many cases situated close to drains contaminated by sewage and so may easily become infected.

The areas not supplied by town water include all the larger cattle stations. Water derived from any source is freely used either for washing utensils or for diluting the milk, and it is to this milk that the cases of Typhoid occurring amongst Europeans who use town water only for drinking purposes is probably to be attributed, as it is often not boiled before use.

There is little likelihood of the disease being either dust born or fly born in this country amongst Europeans. Except on the roads in long spells of dry weather there is little dust and flies occur only in small numbers in well kept houses.

With the Chinese the conditions differ greatly. Town water is not supplied to all parts and surface wells are freely used. Very little unboiled water is used by the Chinese for drinking purposes, but it is used for washing utensils, vegetables, etc.

In the crowded parts of the town dust is present in abundance in houses, gambling farms, theatres, etc. Examination of samples of dust taken from various places of public resort, from lodging houses and brothels, resulted in finding *B. Coli communis* in 66% of the samples taken. Even during wet weather the dust in these places is abundant and easily disturbed. Dust, therefore, cannot be excluded from amongst the sources of Intestinal disease amongst the Chinese.

In some of the Chinese houses flies, *Musca domestica*, and several species of *Lucilia* and *Sarcophagi* are abundant. The Chinese methods of disposal of excreta is probably ultimately destructive to pathogenic organisms, but in the early stages of the process before this destruction has taken place these flies may convey disease.

There is no evidence that the *larvæ* of these flies bred in the excreta harbour as *imagines* the human intestinal bacteria. As far as experimental work has gone even *B. Coli communis* does not seem to be carried in this manner.

In the country districts the water supply is often inferior. Any stream or river passing through a mining district is always contaminated with excrement. Such water can usually be recognised at once, as much of the washings from a mine consist of finely divided white clay which remains in suspension in the water for prolonged periods.

Surface wells are usually contaminated. It is common to find such wells in the immediate vicinity of drains, cesspits, and houses even in moderate sized towns or in Government institutions. It does not seem to be sufficiently realised that the area from which a surface well draws its water is considerably greater than a circle three or four times the depth of the well in diameter.

PLAGUE.

Two cases of Plague were detected in the course of ordinary Post-mortem examinations. Both the patients had been picked up dead or dying in the street and taken to the hospital.

In neither case were there any visible buboes nor were the lungs affected. In both there were subserous hæmorrhages, and in one there was a large perirenal hæmorrhage and in the other there were hæmorrhages into the substance of and on the surface of the left inguinal glands which, however, were not appreciably enlarged.

In both cases the diagnosis was made from smears and confirmed by cultural methods.

Another case occurred in hospital at Kwala Lumpur, a definite bubonic case, also confirmed bacteriologically. The detection of these cases led to the location of the centre of the disease at Kwala Kubu and some 14 cases all confirmed bacteriologically subsequently occurred. Strict isolation of contacts, etc., was enforced, and the epidemic did not assume formidable dimensions. No other cases occurred in Kwala Lumpur. There was a history of mortality amongst rats at Kwala Kubu previous to the detection of the epidemic, and in previous small epidemics rats as well as men have been found to be infected, so that conditions here are such that the disease does spread amongst both man and rats and yet has never spread to any great extent and has always been suppressed shortly after the discovery of each outbreak with very small loss or expenditure. The disease is very virulent and in every known case death has occurred.

CHOLERA.

There was one small outbreak of Cholera near Kwala Kubu. The diagnosis was confirmed bacteriologically. The water from several wells was examined and one in particular was found to be infected and closed. There was no further spread of the epidemic.

No cases of Cholera have occurred at Kwala Lumpur. One case was suspected on account of the symptoms and the character of the stools. The post-mortem appearances were not incompatible with that diagnosis. Bacteriological examinations and cultures of scrapings and of the "rice water" intestinal contents showed the complete absence of vibrios. Almost pure cultures were obtained of an organism indistinguishable from the *B. Coli communis*. Similar suspicious cases seem to occur from time to time. Samples sent either of excreta or intestinal contents in such cases are free from Koch's Cholera organism. In no instance have other cases occurred in relation with them, and the disease appears to be neither infectious nor communicable to any important extent.

SEPSIS.

The deaths from sepsis, exclusive of extensive and gangrenous bed-sores in Beri-Beri cases, include two cases of gangrene of legs; Necrosis, two; Suppurative Nephritis, two, one of them associated with suppuration in the Prostate and the other with renal calculi. In one case there was a large perineal abscess and fistula with ulceration of the duodenum.

There was one case of ulcerative endocarditis, another of acute pericarditis and peritonitis the origin of which could not be traced, and in yet another case there was an abscess in the muscle substance near the apex of the heart. In the last case there was an old sinus in the axilla.

I include in this series a large solitary splenic abscess. As is usual with such splenic abscesses there was no other associated disease and no ulceration of any part of the alimentary tract. No amœbæ were found. The abscess had been opened during life by operation and had also burst into the peritoneum. Various bacteria were found in the contents of the abscess but were probably secondary.

Cultures made from blood or spleen in the cases of Sepsis showed the organisms to be *Staphylococcus pyogenes aureus* and not *Streptococci*. This prevalence of general infections by *Staphylococcus* renders it unlikely that good results could be anticipated from the use of antistreptococic serum.

As regards lower animals. The septicæmia of rabbits is a cause of heavy mortality amongst them. It appears to originate *de novo* and affect simultaneously four or five. Prompt removal of the other unaffected rabbits from the flock and successive removals if any more are attacked usually suffices to limit the epidemic. The organisms are found usually in pure culture both in the affected lungs and in the cardiac blood, and are those commonly described for this affection.

Though fatal to guinea-pigs when injected intraperitoneally it does not seem to be communicable to them under natural conditions.

Hæmorrhagic Septicæmia in cattle has not been observed by me. This disease is so frequently confused with Rinderpest that it is possible some of the described epidemics of Rinderpest may have been Hæmorrhagic Septicæmia, but there is no satisfactory evidence that such is the case. The outbreaks of Rinderpest in 1903 and 1904 were certainly that disease and not Hæmorrhagic Septicæmia.

Rats do not appear to develop any epidemic disease either naturally or in confinement here. Many organisms, some of them occurring in natural waters, were fatal to rats when injected, but other rats confined in the same cages were not infected. The same organisms given by the mouth in food produced no effect. These experiments were made with a view to the destruction of rats, as this is a matter of first importance in connection with Sugar and other plantations.

INFECTIVE GRANULOMATA.

Of the infective granulomata other than Tubercle and Leprosy, Syphilis is the most important. Syphilitic lesions of the internal organs were found in 7 cases and were definitely the cause of death in 2. In many other cases there were external lesions, of the disease. On the whole, considering the frequency of the disease, the small mortality, the absence of cerebro-spinal cases, including *Tabes dorsalis*, is satisfactory.

The only special lesion that is of importance because so often overlooked and so likely to be confused with dysentery is the Proctitis referred to in that connection.

Two of the cases included on account of their symptomology with Malignant disease probably belong to the class of granulomata. In neither case was there any evidence of syphilis.

Yaws occur amongst the Sakies (aboriginal inhabitants) of Malaya in some of the remote districts. *Vide* Report by Dr. GIMLETTE "Notes on some Methods of Employed by Kelantan Malays in the Treatment of Puru or Yaws."

Yaws locally known as "Puru" is also a common disease amongst the Malays on the Pahang River. In every village visited cases were seen in some of the children. Children in arms and up to about 10 or 12 were affected. No cases were seen in adults. Many of the other children had scars from this disease indicating comparatively recent attacks. A considerable proportion of the children are not attacked, and in this the condition differs from that in Fiji where the disease is universal amongst the children. The scarcity of flies and the smaller houses are probably sufficient to explain the difference. Various forms are distinguished by the natives as in Fiji and in the West Indies. These distinctions are based on the arrangement and amount of the eruption on the parts mainly affected. The eruption itself is characteristic and indistinguishable in appearance and in course from the Yaws of the West Indies, West Africa and Central Africa and the "Coko" of the Fijians. A primary sore usually on the feet legs or hands is recognised in most cases. These are the places most exposed to injury and it is probable that infection takes place in the great mass of cases through some breach of the cuticle.

So much has been written on the relationship between Yaws and Syphilis and the statement that Yaws is merely a racial or climatic modification of Syphilis that it may not be out of place here to state that I have now seen Yaws in different races of Negroes, Chinese, Natives of various parts of India, Portuguese, English, Polynesians, Melanesians and Malays, and in the offspring of various combinations of several of these races. I have also seen the disease in such different climates as those of Fiji, British Guiana, Central Africa, West Africa and Malaya. In all these climates and amongst most of these races Syphilis also occurs and the two diseases are easily distinguishable from each other and "breed true."

The disease in Malaya is probably indigenous.

In the lower animals granulomata appear to be uncommon. The granuloma affecting the genitalia of dogs, common in many tropical countries, has not been seen here.

Glanders has been recorded but no case occurred during the period under review.

An imported horse which had been many months in the colony and in apparently good health gradually began to lose condition, a chronic irregular fever set in with exacerbations of more severe fever and later subcutaneous swellings appeared. At first these were only on the hind legs but later on the fore legs also, the abdomen and the neck. These swellings varied in size, they were not hot and were moderately soft. When advanced distinct fluctuation was obtained. The swellings, whether allowed to burst naturally or opened, discharged glairy yellow fluid or thick pus. The ulcers formed healed fairly readily in some instances and in others slowly or incompletely breaking down again.

More of these swellings continued to form as the old ones healed, and later yellow thick fluid streaked and stained with blood was discharged from time to time from the nares.

Blood examination was negative except on the occasion when Mr. FORD found an embryo filaria. The result of injections of blood

into rats and guinea-pigs was negative and so were cultures on various media.

The animal rapidly emaciated, fever continued, and ten weeks after the first observation and little more than three months after the first symptoms were noted the animal was killed. It would probably not have lived more than two or three weeks more.

Post-mortem examination showed no visceral lesions and all the organs appeared healthy.

The vomer was covered to a great extent on both sides by areas of coarse granulation tissue raised above the surrounding mucous membranes. A narrow zone of intense congestion surrounded the smaller areas so affected.

Sections of the subcutaneous tissues and of the growths on the vomer showed masses of round celled growth. The surrounding connective tissue was little thickened. There was no caseation, but towards the centre of the larger masses the cells stain feebly and appear to be degenerate. The vascular supply to the growths is scanty. No organisms were found in the deeper parts of the growth.

The disease appears to be closely related to if not identical with that described in Manila as Pseudofarcy. The resemblances to glanders are entirely superficial. No growths of the organism of glanders were obtained, and injections made into animals susceptible to glanders all failed.

No other instances occurred either in the stables occupied by other horses adjacent or elsewhere, and though a certain amount of care was exercised it would not have been sufficient to prevent the spread of any highly contagious disorder.

MALIGNANT DISEASE.

Malignant growths were noted only in Chinese. The number of Tamils, 32, was too small for any conclusion to be drawn from the absence of such cases, and as no post-mortems were made on Malays no information is obtainable as to the frequency of inaccessible malignant growth in that race.

Malignant growth was present in 10 cases. These post-mortems were in several instances selected and probably represent all or nearly all the cases that terminated fatally from that cause during the period under review. The total deaths were 805, so that the percentage of the deaths was not less than 1.24.

The different age periods of deaths from all causes of those examined was 25 and under, 6.1 %; 30 and under, 22.1 %; 35 and under, 19.6 %, or 50 % under 35; under 40, 16.8; 45 and under, 13.5; 50 and under, 8; 60 and under, 9.4; and over 60, 3.7. These ages must be received with caution and considered as estimates only. Accurate information is not obtainable and in many cases no information at all could be obtained. Of the cases of death from Malignant growth, 7 or 70 % were over 35, i.e., 2 over 50, 2 over 45, 2 over 40, and 1 over 35, and the ages given for the other 3 were 28, 30 and 33 respectively.

Two of the cases were in persons who had been over 25 years in Malaya, and, therefore, must, I consider, have acquired the disease in the country. One had only been one year from China and possibly had not acquired it in this country.

The organs involved are shown in tabular form:—

Liver.	Stomach.	Pancreas.	Lungs.	Orbit.
7	3	2	2	1

In 5 the liver was primarily affected, in two it was secondary to disease of the Stomach or Pancreas. In the Pancreas it appeared to be primary in one case. In the lungs in both cases the growth was secondary. In the orbit it was primary.

The enormous preponderance of Hepatic Malignant growth was not limited to the District Hospital, similar cases were met with at the General Hospital and elsewhere. It is a common feature of the distribution of malignant disease in other tropical countries as in British Guinea, and is not restricted to any one race, as there I have observed it in Negroes, Indians and half castes.

The primary hepatic cases are all of one type and are mainly composed of hepatic cells not cells of the biliary ducts.

Clinically the marked feature and the earliest to attract attention is abdominal enlargement due in part to ascites. The fluid is blood stained in some cases, so much so as to appear to the naked eye to be almost pure blood. This occurred in two of the cases here. Red corpuscles little altered are found in the fluid, and spontaneous coagulation may occur. Sometimes when first tapped the fluid may be clear but at subsequent operations blood stained. There was no jaundice in these cases.

The liver is always enlarged and may be felt to be nodular. The growths are multiple but vary greatly in size and in number. In three the growths were scattered all through both lobes. In the other two one growth was much larger than the others and the other masses were only distributed in the one lobe.

The surface of the growth is always convex and on section shows no cupping or contraction. The consistence varies but is never hard or fibrous and may be so soft as almost to give the impression of fluctuation. The growths show no tendency to break down or undergo any form of degeneration beyond fatty and pigmentary changes. They may be entirely yellowish white and are usually pale in their greater part, but may be parti-colored and sometimes appear to be lobulated.

In one case there were secondary deposits in both lungs but not elsewhere.

On microscopical examination the growth is seen to be composed of large cells, with abundant protoplasm, irregularly hexagonal in shape. The cells differ from normal hepatic cells in that the cells stain more readily with basic stains, are somewhat larger and more irregular. The arrangement is in clumps or columns. The tendency to the formation of columns is more marked in some cases than in others, and occasionally these columns are imperfectly tubular. The fibrous tissue is scanty but more abundant in some cases than in others. In none did it form, even in the central parts of the growth, dense masses. In a few instances the growth was divided by definite fibrous strands and in these in one specimen biliary ducts were present.

There was no definite capsule to the growth, but the surrounding hepatic tissue was formed of hepatic cells flattened and compressed.

In the one instance in which secondary growths occurred in the lungs the central part of each of the pulmonary growths contained cells similar to those in the hepatic tumour but the periphery of each growth was formed of alveoli filled with round celled exudation—secondary pneumonia.

The close resemblance to hepatic cells of the cells of the growth the absence of any alveolar structure and the non-implication of the glands are all in favour of an Adenoma rather than of a true Carcinoma. The growth clinically is Malignant to a high degree.

Classified according to the nature of the growth as determined by microscopic examination. There were Adeno carcinoma or Malignant adenoma, 5 in each case of the Liver. Carcinoma, 2. One of stomach and one of the pancreas. Sarcoma, 1. Granuloma of the Stomach, 2.

The Adeno-carcinoma of the liver is certainly the commonest malignant growth here. Three similar specimens in addition to these mentioned have been sent to me, and most of the Medical practitioners know of other cases. Sarcoma is more common than my figures would indicate. I have received in addition a specimen of Fibrosarcoma of the male breast from Dr. McClosky. An enormous mass weighing 40 lbs. was removed by an Assistant Surgeon at Kwala Kubu from the abdomen at a post-mortem examination and was sent to me by Dr. DELMEGE. This tumour did not involve the abdominal viscera and appears to have been omental in origin. It was lobulated, contained much fat and several irregular cysts containing blood or altered blood and varied greatly in appearance in different parts. In parts the structure myxomatous and in others it was more the type of a spindle celled sarcoma. There were in other places strands of dense fibrous tissue and of imperfectly formed cartilage. There was no ossification. It was one of the mixed sarcomatous abdominal growths and had been steadily increasing in size for some months.

The two cases called "granuloma" are of a type new to me. In both the mucous membrane of stomach was extensively involved. The mass of the growth was imperfectly cicatrised and superficial ulcerated in places. The edge of the growth was raised slightly nodular and sharply defined from the unaffected mucous membrane. The cicatricial tissue was hard and inelastic so that the stomach retained its shape when removed from the body. There was no deep extension of the growth. The glands were not involved and there were no secondary growths in other parts of the body. In one of the cases the whole of the mucous membrane of the stomach was involved and the growing edge extended into the œsophagus and duodenum respectively. In the second the pyloric half of the stomach alone was involved.

Microscopically the growth was a round celled mass with outlying smaller masses not sharply defined. These scattered portions of the growth were found in the cicatricial tissue and in advance of the growing edge which was entirely composed of the growth.

No tubercle or other bacilli were found in the depths of the growth and there was no evidence of syphilis.

Specimens of Peritoneal Malignant growth in a dog and in a fowl were sent to me by Mr. Ford. In both cases the growths were extensive and were sarcomatous in structure.

General Conclusions.—Our main knowledge of diseases is of those imported into the States and of indigenous diseases as they affect imported races.

Effective quarantine combined with notification of infective diseases and local action are the main points on which to rely against the further importation of disease. In certain cases the effect of other measures should be to render conditions unsuitable for the spread of disease if imported. Amongst such measures a water supply free from chance of contamination will hinder

or stop the spread of introduced Cholera or Typhoid. The destruction of breeding places for *Stegomyia fasciata* will prevent the dissemination of Yellow Fever and that of rats limit the probability of the spread of Plague.

The most important of the indigenous diseases are Malaria and Dysentery. Further details as regards the causation of these diseases are given elsewhere. The main peculiarity of Malaria in this country is that it is a disease of hilly country and of certain alluvial districts near the sea, and that during clearing and draining such places are bound to be unhealthy. This period should be shortened as much as possible as when cleared or drained they cease to be malarious.

The most serious diseases probably imported but now firmly established are Beri-Beri and Tuberculosis.

Beri-Beri appears to be of rapidly diminishing importance, and though the true causation is obscure we do know that every improvement in the welfare of the people will further reduce its importance.

Tuberculosis on the other hand is steadily and rapidly increasing and unless energetic measures are taken promises to be the important fatal disease of the country.

Attention to sanitation in its widest sense and expenditure on it would in my opinion be even pecuniarily remunerative.

NOTES ON CERTAIN INSECT PESTS AFFECTING PLANTS.

The insect pests of the vegetable kingdom in the Malay States are numerous and destructive. In the grounds of the Institute a considerable amount of food has to be grown for various animals and in addition fruit trees and certain plants of economic value are cultivated.

It was hoped that those interested in such subjects might have been able to make a special study of the diseases of such plants as it could be more safely done in an isolated tract of land than in an agricultural district.

Certain preliminary observations have been made by the staff of the Institute and they show that the distribution of disease of this kind in the Federated Malay States requires careful and local study.

Sugar Cane, *Saccharum Officinarum*.—The "borers" affecting this plant in the large Sugar estates in Province Wellesley were the subject of a special study by Mr. RIDLEY, the Straits Settlement Government Botanist. He showed that the worst pest was a lepidopterous larva *Chilo saccharalis*, but that the canes were also attacked by larvæ of two species of Coleoptera *Sitophilus sculpturatus* and *Xylotrupes gideon*. In Selangor in the neighbourhood of Kwala Lumpur none of these borers are found but instead borers of two lepidoptera one, a Zeugnerid, which is very common and destructive and a smaller rarer one which does comparatively little damage. This moth, according to Mr. ROBINSON, is closely allied to *Phragmataecia castaneæ*.

The Zeugnerid larva commits worse ravages than I have seen in any other part of the world in Sugar cane. If the caterpillar penetrates near the top of the cane the growing point is completely destroyed, if nearer the middle the growth is much retarded and the young segments formed are short and thin but if the cane survives later segments may attain nearly the full growth.

If the borer perforates the canes near the ground secondary effects frequently result, either termites obtain access and eat out the whole of the

interior of the cane for two or three segments, so destroying it, or ants get in and probably by carrying in and depositing earth set up destructive decay.

The first borers were noticed in cane about 4 months old. The older the cane the larger the proportion attacked. In ratoons practically every cane is affected.

The smaller borer beyond causing some diminution of the growth is comparatively harmless. It is identified by Mr. ROBINSON as a Crambid.

In Pahang none of the borers which were found in Province Wellesley and Selangor were found. In a few canes on the East Coast a lepidopterous larva, according to Mr. RIDLEY, a Pyralid, does occur, but the destruction caused is small. It has not been found elsewhere in the Federated Malay States.

It is noteworthy that the native varieties of cane are far less attacked by these pests than the imported varieties.

The original source and native habitat of these borers is unknown. The wild *Saccharum arundinaceum* is not attacked.

Scale insects are abundant in the axils of the leaves and appear to cause some destruction in ill-kept badly cleaned canes.

Till full information is obtained as to the distribution of the pests and particularly of the Zeuzerid larvæ great care should be exercised in moving canes from one place to another or this pest may be introduced and possibly under European conditions of cultivation thrive in districts at present free from it. I do not believe that on a large scale cane could be economically grown in any district where this pest occurs.

Indian Corn, Maize, *Zea mais*, is not very extensively grown. It is not as in Africa the staple article of diet of any class. It grows well in manured land and can be cropped in from 10 to 14 weeks according to the weather. Few pests seem to cause much damage but the cobs are frequently attacked when nearly mature by a lepidopterous larva which in its passage up the cob destroys a certain number of the grains. The dry cobs are attacked by weevil, probably, according to Mr. H. C. ROBINSON, a Calandrid.

Millet, *Sorghum vulgare*—Like Indian Corn is only grown as a subsidiary article of diet. The native varieties have few and poor heads with small seeds. A West Indian variety introduced has numerous heads and large seeds and grows rapidly and affords an abundant crop. The young shoots are often destroyed by mole-crickets, and one of the few aphides found in the country is found on this plant.

The heads and nearly mature seeds are the parts most subject to disease and are attacked by two larvæ of lepidoptera both belonging to the Pyralid family as identified by Mr. ROBINSON. These heads are also liable to be attacked by fungus (smut) but whether secondarily to the attacks of larvæ or not could not be ascertained. The native variety of millet is not attacked by these insects.

The flowering stalk is often hollowed out by an adult hymenoptera or solitary wasp, a Sphegid.

Fruits of various kinds are subject to great variety of insect pests. The grenadilla, *Passiflora quadrangularis*, is much infested by Thrips in some cases and these destroy the pollens and tips of the stamens, according to Dr. LEICESTER, and so prevent fertilisation. Only some vines are so infested. When nearly mature dipterous larvæ are found in the thick seed

case and cause necrosis. If they penetrate into the interior of the seed the fruit is destroyed.

The soursop, *Anona muricata*, in some parts of the country particularly on the East coast is attacked by scale insects. These may be so numerous as to almost entirely cover the fruit and soon destroy it. Many other fruits are attacked by dipterous larvæ.

The trunk and larger branches of the soursop are often attacked by a bark caterpillar which in the earlier stages does little harm but before pupating burrows into the axil of a small branch and there pupates. In the cavity thus formed small black ants speedily resort and the branch usually dies.

Though the number of caterpillars attacking leaves, etc., is large the actual destruction caused is less than might be expected. One of the most destructive of the leaf caterpillars is the *Ereonota thrax* which lives on the leaves of all varieties of the Banana including the wild or jungle species. This caterpillar causes much destruction of the leaves as it separates a portion from the midrib and curls up this portion. Protected in the interior of this curled up portion the larva remains and eats at the edge of the leaf. Only a small portion is eaten and then the caterpillar proceeds to strip off another portion of the leaf which is similarly destroyed and finally it pupates in the centre of another curled up strip of the leaf. A single caterpillar therefore destroys a portion of the leaf far in excess of what it eats.

The stem of the banana is attacked by a Coleopterous borer—a weevil. The borer penetrates obliquely into the centre of the stem. A secondary decay occurs along the course of the track and the stem frequently breaks two or three feet from the ground whilst the plant still appears to be fairly healthy.

In other cases the central growing shoot dies whilst the rest of the plant appears still to be healthy.

The fruit are sometimes attacked by Lepidopterous larvæ.

Tubers of the sweet potato *Ipomoea batatas* are often destroyed by a small beetle larva, a Curculionid. In such a tuber every stage, the small larva, the pupa and the imago, will be found and the root will be riddled with the tunnels eaten out by these pests. Of the varieties of the sweet potatoe grown in the F. M. S. the whiter varieties are much more extensively attacked than the red ones even when they are both grown together.

The main stem of the sweet-potato is sometimes attacked by a Lepidopterous borer. The borer track extends along the stem below the ground and the whole plant dies.

On the whole the various scale insects and homoptera are probably responsible for more destruction than any other order. None of the species of orange, limes, etc., which in most tropical countries do so well are successfully grown in this country except in a few places. The *Lecanium irride* and a small black scale insect appear to be responsible for the poor growth of these plants.

A similar scale insect to the *Lecanium viride* attack the Cinnamon and many other trees, whilst scale insects of various species abound on both forest and cultivated tree. Some of these form leaf galls, some attack young shoots and others leaves, leaf stems, or other parts of the plants.

It seems to me advisable to publish these few notes as the subject is of vast importance but has attracted so little attention from the general public.

I am quite aware that much good work has been done on the subject by Mr. RIDLEY, ROBINSON, and others, and that isolated papers have been published and facts recorded, but a more systematic and complete investigation and publication of results in an accessible form is a matter, in my opinion, of urgency, as many insects with the increase of planting may find improved conditions of existence and become more widely destructive.

Specimens of the various insect pests found have been sent to the Museum for identification.

PART II.

A Preliminary Report on Natural Waters and the Effects of the Methods of Purification Adopted.

WATER SUPPLY.

General.—Intestinal diseases are the cause of so large a part of the mortality amongst the inhabitants of all nationalities of the Federated Malay States that an examination of the existing water supplies becomes of the highest importance.

Little has been published as to the minute flora of jungle streams in so uniform a climate as that of Malaya. The thick jungle and the heavy undergrowth provide abundance of vegetable matter to serve as a medium for the growth of organisms. These streams are so shaded that they are not exposed to direct sunlight or even to a strong diffused light and the temperature varies little from day to day or from day to night and is usually about 80 F. at the lower levels.

Under these conditions, as might be anticipated, the organisms are abundant and differ in type from those met with in temperate climates or in tropical climates where the rainfall is less uniform and vegetation not so rank.

The places selected for examination were, with certain exceptions, places where the chances of contamination with the excreta of man or of the domesticated animals were very small.

Jungle streams are the sources of nearly all the water supplies and are most of them in granite country. Samples were taken from streams, at an elevation of over 3,000 feet, on Treacher's hill, both from the side of the hill on which the Government Bungalow is situated and where slight contamination is possible and from the other side where no such contamination could take place. Other samples were from the streams entering the reservoir at the Ampang Water Works. The catchment area is rigidly reserved for the town water supply. From a similar stream and reservoir for the small island of Pangkor Laut and from the service reservoir supplied with unfiltered water at Klang. These sources are taken as examples of the natural water under natural conditions and unpolluted by man.

Other samples where the possibility of pollution was great were certain streams, surface wells, etc.

Method of examination employed.—The water was collected in sterilised bottles and carried, packed in ice, to the laboratory and examined as soon as possible.

The routine examinations consisted :—

(1) Of plating a known volumes of the water on agar or gelatine, or both.

(2) Of inoculating with varying amounts, .4, 2 and 5 cc. were the usual ones, a tube of MacConkey's medium, Bile salt glucose broth.

(3) Plating on agar and gelatine from the 20 to 24 hour old growth in this medium.

(4) Addition to Peptone water of 5 cc. and sometimes of other amounts of the water to be examined and testing for Indol at the end of 48 hours.

As determined by plating the number of organisms in all natural waters is very high as compared with European standard and the number when cultivated at blood heat is as great as at room temperatures and higher as a rule than in gelatine plates at 22° C.

For purposes of comparison the plates used were of Agar-Agar made with Liebig's Extract and neutralised so as to be of an alkalinity + 10 as tested by Phenolphthalein. The plates were kept at a temperature of 37° C., and counts were made up to the 5th day. Few new colonies are found after the third day whether the plate be kept at 37° C., in the cold incubator at 22° C. or at room temperature.

MacConkey's medium is, in my opinion, of particular value, and the absence of the formation of acid and gas within 24 hours is a certain proof of the purity of the water. It is not a test of sewage contamination as many natural waters will give the reaction even with .4 cc. or less. Amongst these waters is that found in the stems of upright growing bamboos which have been perforated by a borer and in which water is found. In such a stem with an aperture from $\frac{1}{4}$ to $\frac{1}{8}$ of an inch any contamination by animals except insects and other small invertebrates is impossible. The value of the medium is that it is a crucial test of the purity of water.

Plating from the growth in this medium is of considerable value.

For this purpose it is essential that young cultures preferably 24 hours old should be used as the more delicate organisms, those most closely related to the human intestinal organisms, pathogenic or non-pathogenic, are destroyed in the acid medium into which this medium is converted by the growth of organisms. If plated from older cultures, these organisms may not be found.

Plating from this bile salt broth in Gelatine is best as it is the non-liquefying organisms that are of importance.

In this manner from nearly all such waters short bacilli can be isolated which decompose glucose or lactose or both with the formation of gas or with the formation of acid only. They are non-spore forming are usually motile but vary in motility. They do not retain their stain when treated by Gram's method. Only a few of them curdle milk and that not for three or four days as a rule.

Few of them form indol and none indol and nitrites. Some are not pathogenic to rats or guinea pigs whether injected subcutaneously or into the peritoneum. Others are fatal when injected intraperitoneally but not when injected subcutaneously. An extensive local slough or pus may be caused or no lesion at all may result from the subcutaneous injection.

In appearance of growth they are often indistinguishable, and in any case from the non-pathogenic to the most virulent there is no more difference in the growth on Agar, Gelatine, Potato, etc., than in various laboratory strains of *B. Coli communis* to which organism they appear to be related.

The presence of these classes of organisms in minute samples of the water is indicated by the use of MacConkey's medium. Though not of the same importance as that class of organisms would be in a temperate climate I consider that such water should be viewed with suspicion.

It is rare to find water absolutely free from this class of organism when large quantities are tested. I consider that as a practical standard water could be passed as good in which no acid and gas formation occurred with MacConkey's medium in 24 hours with 2 cc. of the water to be examined.

Indol formation is much less common with the same bulk of water than the reaction with MacConkey's medium. The natural waters which contain the indol forming organisms also give the MacConkey's reaction though not necessarily vice versâ. In some instances though no Indol is formed in 48 hours from the water the deposit from this water contains organisms which will form Indol.

In practice I use 5 cc. of the water and add to peptone water and test for the reaction in 48 hours.

Even where 5 cc. give a reaction with MacConkey if no indol is formed in this time the probability that the water is injurious is decidedly diminished.

In giving an opinion of a sample of water it is, I think, advisable as a basis to consider:—

(1) The number of organisms exclusive of known easily recognised non-pathogenic organisms, e.g., *B. subtilis*, *B. megaterium*, *B. prodigiosus*, *B. violaceus*, and some of the organisms which form characteristic yellow colonies which have been proved to be non-pathogenic to lower animals.

(2) The amount of the water required to react, forming acid and gas, with MacConkey's medium, 2 cc., 1 cc. and 2 cc. will give a sufficient range for the natural waters here.

(3) Indol formation in 48 hours in Peptone water with 10 cc. 5 cc. and 1 cc. of the water to be tested.

STANDARD.

As a standard Dr. FINLAYSON, the Government Bacteriologist, Singapore, and myself have suggested that:—

(1) Not more than 100 organisms exclusive of those mentioned should be present in a 1 cc. of water.

(2) That no acid and gas should be formed in 24 hours in MacConkey's medium at 37° with 2 cc. of the water.

(3) That no Indol should be formed in Peptone water in 48 hours with 5 cc. of the water added.

This standard is not a high one but it is exceptional to find a natural water that will pass all three standards.

JUNGLE STREAMS.

From the streams at the higher altitudes the number of organisms in one stream varied from 155 to 205 and another from 115 to 190 per cc. In both the highest determinations were after heavy rain. As the temperature at this time was at night down to 60° F. and there was no cultivated manured

land in the catchment area and in one of the streams no human habitation this compares unfavourably with hill streams of a similar character in temperate climates.

In the water from both streams 5 cc. give a good reaction with MacConkey's medium in 24 hours but not with 2 cc. or 1 cc. No indol forming organisms were found in 5 cc. of either. These waters, therefore, may be considered as fairly good.

Four streams were examined at Ampang. These form the main supplies to the Reservoir. The catchment area, now 1,500 acres, is rigidly preserved. There is no cultivated land in the area and no human habitations or domesticated animals, but there is a certain amount of game. The hills are of granite and thickly covered with trees and jungle.

The streams varied from each other and from time to time and the number of organisms was affected by the rainfall. After long continued dry weather the lowest number was obtained 104 per cc., but after very heavy rain, 2 in. in 12 hours, the number 148 was not much greater. With moderate rains after a spell of dry weather the highest reading 2,120 was obtained.

As regards the four streams in ordinary weather 400 to 800 organisms per cc. were found. Most of the observations were made in June and July by Dr. FINLAYSON and myself. Previous observations had been made in October, 1903, and in January, 1904, with similar results.

With MacConkey's medium acid and gas forming organisms were found to be present in each stream, but the amount of water required to give the reaction varied from time to time. With .1 cc. at one time three of the streams gave the reaction and with .4 cc. the other.

At other times no reaction was obtained with 2 cc. but this was highly exceptional and a positive result was always obtained with 5 cc.

Indol forming organisms were not always present in 5 cc. of the water but were always found in the sediment from the water. Examination of the stream water at the small granite island Pangkor Laut gave very similar results, 300 to 500 organisms were found per cc. Acid and gas forming organisms were present in 1 cc. and Indol forming organisms in 5 cc. No cultivated land, no human habitations and no domesticated animals existed in the catchment area but wild pig were abundant. None of these waters can be considered as satisfactory from the bacteriological point of view.

The Public Health question is a difficult one. The character of the catchment areas in these places renders sewage contamination impossible and the risks therefore of diseases such as Typhoid and Cholera which are conveyed only from man to man by the contamination of the food, water or other inješta with ejecta of persons suffering from these diseases can be definitely excluded.

The existence in nature of classes of organisms closely related to the human intestinal organisms capable of living and multiplying in artificial media at temperatures and in the presence of substances such as bile salt inimical to many natural organisms and which are pathogenic in various degrees to the lower animals, is a matter of great importance.

It is difficult to exclude the possibility that such organisms are agents in the prevalence of intestinal disease amongst persons travelling or working in the jungle.

The history of the occurrence of dysentery amongst the troops engaged in the Bentong Expedition is of interest in this connection.

Dr. TRAVERS informs me " that in the year 1891 a force of some 150 Sikhs and Pathans with coolies and others were camped at Bentong in Pahang for about six weeks. The water for the camp was taken from a river which ran alongside, it was clear bright palatable water. After a few days some 20% of the force was attacked with dysentery some of them being seriously ill. Of eight Europeans four were attacked. On the outbreak of dysentery he at once had wells dug and all the camp had to drink the well water. The result was very satisfactory. The dysentery practically disappeared and with one or two exceptions the men remained healthy. Only a few small Malay Settlements existed in the catchment area and care was taken to get all the water from above the camp."

Such histories are not uncommon in countries thickly covered with jungle where the rainfall is abundant and streams are plentiful. With either small or large parties under such conditions dysentery so frequently breaks out even when no permanent camps are formed and care is taken that no fouling of the watercourses takes place that it is difficult to exclude natural sources of dysentery, apart from human contamination, from consideration.

Ship epidemics and some of the gaol epidemics also go to prove the origin "*de novo*" of some outbreaks of dysentery though no doubt once started human agencies are important factors in the spread of disease.

Of well known organisms common in these waters *B. subtilis*, *B. megaterium*, *B. violaceus*, *B. prodigiosus*, *Sarcina lutea* and various Cocci and moulds may be mentioned. They all grew well at blood heat and both *B. prodigiosus* and *violaceus* continued to form pigment under that condition. *B. pyocyaneus* was only found once in any of these waters but does occur in some well waters. Other organisms which we could not identify were common.

SURFACE WELLS.

Examinations have been made immediately after taking the sample of the water from surface wells in the neighbourhood of the Institute. In such the number of organisms is of some importance.

Other examinations are of water from wells collected in various parts of the State. These have been sent by train and delay has occurred sufficient for further development of organisms so that the class of organisms present alone is of importance.

No precautions are taken as regards surface wells beyond making a raised edge some 2 feet 6 inches round the well which prevents frogs, etc., from entering and having the surface of the ground round the well sloped from the well to a drain some 6 feet or less from the edge of the well. This surface is usually concreted. These precautions serve the purpose of preventing water used for bathing, washing utensils, etc., from directly running back into the well. Many of the wells are 24 to 30 feet deep and the surface of the water is rarely less than 6 feet below the ground in dry weather.

The drainage area of such a well is much greater than the small area enclosed in the drain and in dry weather may be so cracked and fissured that water discharged on the surface and containing surface washings may be discharged directly into the subsoil water which supplies the well.

Outside the limited area mentioned but inside the area from which the supply of the well is drawn may be seen native houses with cess pits attached as at Port Dickson, main drains from market places as at Rasa, drains from hospitals, post-mortem rooms, etc., as at Kwala Lumpur, and in practically no case is there a proper sufficient reserve area to prevent occasional or habitual contamination of the well water.

Where wells are necessary, and this is often the case, with sufficient precautions against contamination surface well water is probably better than stream water. No precautions can be sufficient where there is a crowded population and the ground is soaked with human discharges. A certain amount of filtration and purification of the water no doubt occurs and further purification takes place by sedimentation, but I contend that where obvious sources of contamination exist the occasional purity of the water as determined both by bacteriological and chemical methods is no justification of its continued use. Such wells should be closed or the source of contamination removed.

The water from 27 wells in all was examined and of these in only 4 instances could the water have passed as "good" in accordance with the low standard proposed by Dr. FINLAYSON and myself.

In all the others acid and gas forming organisms were present in 2 cc. and usually in 4 cc. of the water, and Indol forming organisms were present in 5 cc. of 10 or more than one-third of the waters examined.

The number of organisms in the wells near the Institute varied from 110 to 1,800, but 350 to 900 were the common limits. *B. pyocyaneus* was found in one instance and in two organisms indistinguishable from *B. coli communis*. No other pathogenic organisms were isolated from these waters, but during an outbreak of Cholera at Rawang vibrios apparently identical with Koch's Comma bacillus were found. Indol and nitrites were rapidly formed in Peptone water and liquefaction of gelatine took place at a rate corresponding to that of that bacillus. It may be mentioned in this connection that the closing of the wells in the Pudu gaol was followed by the disappearance of cholera from that institution and that the closing of the suspected wells at Rawang was followed by a similar result.

In the wells examined most of the commoner non-pathogenic organisms are present and a considerable number of apparently new organisms have been isolated but there is no evidence that they are of any pathogenic or practical importance.

TOWN SUPPLIES.

The water supplies to the larger towns are collected from such streams as those described. The catchment areas are strictly reserved and no settlements are allowed to be made on them.

The water is collected in impounding reservoirs, that at Ampang with a capacity of 37,710,000 gallons for the supply of Kwala Lumpur is at an elevation of 396 feet, and with or without filtration conveyed in pipes to a service reservoir at 1,740,000 gallons in or near the town from which it is distributed as required.

Unfortunately sufficient allowance was not made for the increase in town populations and therefore the works are on too small a scale. The size of the service reservoir necessitates filtration at the maximum speed

during the day and a reduced speed during the night thus testing too severely the working of the filters. The impounding reservoirs in protracted dry weather get too low and any heavy shower in any part of the catchment area may result in stirring up the whole body of water in the reservoir and nulifying the effect of the previous sedimentation.

The Acting State Engineer, Mr. W. E. KENNY, and the Executive Engineer of the Water Works, Mr. J. E. BACH, have kindly supplied me with particulars of the water supply for Kwala Lumpur from which the following figures are taken :—

Catchment Area, 500 acres, an additional 1,000 acres has recently been included.

Capacity of Impounding Reservoir, maximum 37,710,000 gallons.

Capacity of Service Reservoir, 1,740,000 gallons.

Supply daily to Kwala Lumpur, 540,000 to 450,000 gallons.

Average consumption per head per diem $12\frac{1}{4}$ gallons.

The water from the reservoir taken about 2 feet from the surface is delivered to each filter by a bell-mouthed inlet 2 feet in diameter about 1 ft. 6 in. above the level of the sand. The filter bed is 60 feet below the level of the reservoir and heavy stones are placed round the inlet and above the sand to break the force of the water.

The filter beds are 127 feet by 66 feet at the level of the sand and 7 feet deep from floor to coping.

The filtering material consists from below upwards of :—

(1) A layer of bricks on edge in rows $4\frac{1}{2}$ inches apart resting on the concrete floor.

(2) A layer of bricks laid flat about $\frac{1}{4}$ inch apart.

(3) A layer of broken stone 12 in. deep. The stone at the bottom is broken to gauges of $2\frac{1}{2}$ inches and at the top about $1\frac{1}{2}$ inches.

(4) A layer of coarse clean quartz sand 2 feet deep with about 4 inches at the top of rather finer sand.

In long continued dry weather when the flow of water into the reservoir was steady and moderate the effect of subsidence was marked. On two such occasions only 51 and 66 organisms were found per cc. and in the inlet to the filter bed only 24 and 51 respectively. After heavy rain, 2 in. in 12 hours, the whole water in the reservoir was stirred up and muddy and as many as 8,800 organisms were present per cc. These were the two extremes on two other occasions 120 and 150 organisms were present but 300, 400 or 500 with intermittent dry and wet weather when the supply to the reservoir was in excess of the discharge from it were the common results obtained. Four days after the highest number though the rain had been moderate the number of organisms found was still 1,655 per cc.

It is clear therefore that under the climatic conditions present in Malaya small or medium sized reservoirs cannot be relied on to purify the water by subsidence and that the results of storage in such a reservoir will be intermittent as in dry weather water purer than the intake will be obtained but in rainy weather water of worse quality will be discharged than that which enters it.

In MacConkey's medium even when the smallest number of organisms were present a reaction was obtained with 1 cc. of the water but not with .4 cc. No Indol was formed with 5 cc. of the water.

With the largest numbers of organisms 8,800 and 1,655 even in .1 cc. acid and gas forming organisms were present and Indol and nitrites were formed with 1 cc. of the water.

On all occasions in 2 cc. acid and gas forming organisms were found but the presence of Indol forming organisms in 5 cc. was not constant.

The filter bed slopes slightly to a small sump at the southern end into a well 7 feet in diameter and 8 feet deep. From this well, the filter well, the water is discharged into the main to the service reservoir through a vertical telescopic pipe. The rate of discharge is regulated and the filter head is regulated by the height of this pipe but the inflow to the filter bed can also be regulated. The maximum capacity of the main is 60 cub. feet per minute which corresponds to a filtration rate of 2.71 gallons per square foot per hour and this rate is now constantly maintained from 6 a.m. to 6 p.m.

After scraping the main a discharge of 72 cub. feet per minute with a filtration rate of 3.25 gallons per hour was obtained but this has not been maintained. No such rate of filtration should be allowed. The object of a filter bed is defeated if water is passed through at such rates.

The longest run of any filter bed since Mr. BACH has been in charge was $3\frac{1}{2}$ months. This was during a dry period and no water could be spared to wash the second filter bed. When this filter was emptied the sand was discoloured to a depth of 13 in. Only the remaining some $\frac{1}{2}$ inch of sand appeared to be clean but the stones beneath also appeared to be quite clean.

There is no difficulty whether the filters are clean or dirty in obtaining the maximum discharge that the main can take until the loss of filter head is nearly 3 feet. The depth of water on the sand is regulated by a valve in the intake and it is usually kept at rather over 3 feet.

My first examination of this water was on 29th October after a run of 116 days. At this time the depth of water on the filter was 4.7 in., the filter head 2.8, and the discharge per sq. foot of filter bed 2.05 gallons per hour.

The second examination on the 15th January was made after a run of 27 days, the depth of water on the filter was 3.5 feet, filter head .30, and the discharge 2.71 gallons per square foot.

TABLE I.

Date.	October 29.			January 15.			June 9.		
Depth of water on sand ...	4.7			3.50			3		
Reservoir Level	...			...			...		
Filter Head	2.8			.3			.55		
Rate of Filtration	2.03			2.71			2.71		
Rain in previous 24 hours ...	...			3.76			Nil.		
Remarks	Run 116 days.			Run 1 month.			Run 47 days.		
	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.
Intake	750	+	+	750	+	+	1,265	+	+ .4cc.
Reservoir	266	+	+	3,500	+	+	325	+	+
Inlet to Filter Bed	...	...	...	...	...	...	245	...	...
Filter Well... ..	209	+	— .5cc.	716	...	— .5cc.	413	+ .5cc.	+ .2cc. .4cc.

The other examinations were made mainly in conjunction with Dr. FINLAYSON, and details of the conditions which may have affected the working of these filter beds are given separately.

The results of filtration are shown in the subjoined table. The number of organisms in the intake is not for this purpose of much importance as only one or two of the intakes were examined on each occasion.

The water in Reservoir was taken at the same place on each occasion and as a check on this and also as giving a better test of the water actually filtered samples were taken from the water at its entrance to the filter bed. Usually this water gave slightly better results than that taken from the impounding reservoir itself.

TABLE II.

Date.	June 9.			June 13.			June 15.			June 20.			June 22.			June 24.			June 28.			July 6.			July 14.		
Depth of water on sand ...	2.32			3.02			3.14			2.62			2.72			2.4			2.62			2.66			2.6		
Reservoir Level ...	...			...			...			...			...			18			17.5			16.5			15		
Filter Head... ..	.15			.17			.17			.20			.20			.22			.22			.26			.28		
Rate of filtration ...	2.6			...			2.6			2.6			1.66			1.44			2.6			2.52			1.2		
Rain in previous 24 hours ...	Nil			Nil 2 days.			Nil 4 days.			2.58			Nil.			Nil 4 days.			Nil 2 days.			Nil 10 days.			.28		
Remarks	in previous 48 hours .86			Filter changed 15 hours previously.			Rate of filtration reduced for test purposes.			Rate reduced for test purposes for 15 hours.			Half rate at night.			...			...			...			...		
	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.	No. of organisms.	Indol formation.	MacConkey's medium. Acid and gas formation.
Intake	1,265	+	+ .4cc.	250	—	— .2cc.	104	+	+ .4cc.	148	—	+ .4cc.	2,120	+	+ .2cc.	649	—	+ .4cc.	1,496	+	+ .4cc.	500	+	+ .4cc.	825	+	+ .2cc.
Reservoir	325	...	+ .4cc.	55	...	{ + .5cc. — .2cc. }	66	—	+ .4cc.	8,800	+	+ .4cc.	1,248	+	— .4cc.	1,655	+	+ .4cc.	500	+	...	120	...	...	150	—	+ .2cc.
Inlet to Filter Bed ...	245	...	+ .4cc.	24	—	— .2cc.	51	—	+ .4cc.	5,500	+	+ .4cc.	941	+	+ .4cc.	—	+	+ .4cc.	577	+	+ .4cc.	180	+	+ .4cc.	150	—	+ .2cc.
Filter	1,290	+	+ .4cc.	230	—	{ — .1cc. — .2cc. }	258	—	— .4cc.	252	—	— .4cc.	73	—	{ — .5cc. — .2cc. }	96	—	{ — .5cc. — .2cc. }	209	—	{ — .4cc. — .4cc. }	150	—	{ — .4cc. — .4cc. }	275	—	{ — .4cc. — .2cc. }



EFFECT OF FILTRATION.

At first sight the results of the filtration are most disappointing as instead of the reduction of 90 per cent. in the number of organisms obtained by filtration in English and Continental filter beds the number of organisms in the filtrate was actually greater on some occasions than that in the water entering the filter bed.

On closer examination, however, it is seen that when most required and the number of organisms in the reservoir is greatest an enormous reduction is made in the number of organisms. The use of the filter beds prevents the influx of the washings of the streams and render the quality of the water uniform independently of the weather.

Further an examination of the character of organisms in the filtered water shows that nearly all are spore bearing non-pathogenic organisms and that a large proportion are *B. subtilis*.

As tested by MacConkey's medium the results for some weeks were quite satisfactory as, excluding the examination made after the filter had been in use for 15 hours which of course was too early for bacterial filtration to take place, it was not till the bed had been in use 28 days that the acid and gas forming organisms were numerous and even 8 days later they were reduced in number by the filtration.

Indol forming organisms were not present nor were they at other examinations made of the filtered water 1 month, 7 weeks, and 116 days respectively after the use of the filter bed had been commenced.

The beneficial effects of filtration are seen from the table to be :—

(1) The removal for a prolonged period of indol forming organisms.

(2) The removal for a shorter period of a large proportion of the organisms which form acid and gas in MacConkey's medium.

These two classes are those most likely to be dangerous to man.

(3) Equalisation in the number of organisms present and protection of the town supply from the first washings of the ground after heavy rain.

These effects are, in my opinion, quite sufficient to show the necessity of filtration.

The organisms which at first pass through the filter are all spore bearing organisms usually very similar to *B. subtilis*. In some of the earlier determinations 80 to 90 per cent. of the organisms present in the filtrate were of this class.

In the examinations made after 3 weeks the other organisms were present in constantly increasing numbers so that under the conditions of work of these filters they should only be used for a comparatively short period, not more than a month to get good results.

In Europe and in temperate climates a filter can be run for much longer, but no doubt the higher temperature and greater variety of organisms are factors in the more rapid growth through the filter bed of organisms.

It is important, if possible, to prolong the period of use of a filter bed and also to obtain greater efficiency. It will be noted that filtration has

been effected at such a rate as to give to the maximum supply the main is capable of taking about 2.7 gallons per square foot per hour. This is a high rate and though not higher than in use in some waterworks is nearly twice that recommended as safe in Europe by some authorities and is in excess of the usual rates.

The effect of a lower rate of filtration is well shown in the results obtained on June 22 and 24, but when the organisms have grown through the bed as on July 14 diminished rate of filtration no longer produces this good result.

A constant lower rate of filtration would result in a purer water and enable the filters to be used longer.

With the present service reservoir and water supply to the town it is necessary to filter at the maximum rate during the day whilst this rate has to be reduced at night by one-third.

Increased filtration area is necessary. An increase in the capacity of the service reservoir would enable the rate in the day and night to be equalised but the reduction in the rate would not be sufficient.

How far slower filtration will prolong the life of a filter bed and whether additional thickness of sand and use of a finer sand on the surface would improve matters can only be decided by observation of effects of such changes.

A small experimental filter bed in the vicinity of a laboratory would enable such experiments to be made and lead to more economical and efficient work.

The water supply as distributed to the town has been tested at a few stand pipes only. Some of the results correspond closely to those obtained from the water at the service reservoir, but in others much greater differences are observed and the variations are not constant and depend apparently on local and temporary circumstances.

The more thickly populated part of the town is well supplied with water but large areas including all the places where cattle are kept are dependent on other sources and surface wells are still extensively used.

KLANG WATERWORKS.

The Klang waterworks provide unfiltered water to a population of some 5,000 people and it is also the intention to supply the shipping at Port Swettenham as well as the township there.

The impounding reservoir is a natural valley of varying depth dammed up at the lower end. Some parts are quite shallow. The capacity is given as 3,928,984 gallons and the catchment area to supply this reservoir is 340 acres.

The rainfall is less than on the Ampang catchment area and the ground more porous so that much of the lighter rain sinks into the ground. For storage during a spell of dry weather broken only by light showers this reservoir has proved to be insufficient.

The water from this impounding reservoir is conveyed by pipes, some 8 miles, to a service reservoir with a capacity of 563,284 gallons. From this service reservoir the town of Klang is supplied and also a large tank of 26,475 gallons which serves for the supply to Port Swettenham.

The water is not filtered and examination of the water in the service reservoir at Klang shows that acid and gas forming organisms were present

in .2, .5, 2 and 5 cc., and Indol forming organisms in 2 cc. and 5 cc. of the water. The amount of purification by sedimentation is, therefore, insufficient, and the water cannot be considered as good.

The examinations were made during a period when there were light rains only and so under favourable conditions. With heavy rains the water in the shallow impounding reservoir is stirred up and much worse results would no doubt be obtained.

AMOUNT OF WATER.

The water supplied is equivalent to $12\frac{1}{2}$ gallons per head of the population of Kwala Lumpur, but as water is used by the railway, is used for flushing public latrines and occasionally for watering the roads the actual amount supplied per head is much less.

In addition to drinking water much water is rightly used for bathing by all races especially by the Chinese and Malays. The allowance of water is, therefore, very small. A minimum of 20 gallons per diem would be too little.

Even if this minimum is taken as a standard the amount required for Kwala Lumpur exclusive of that required for the railway, etc., would be about 740,000 gallons per diem and for Klang, exclusive of the supply to steamers, railway, etc., about 100,000 per diem.

This corresponds to rather more than 2 and 4 days supply respectively from the service reservoirs and is in great excess of that supplied by the main which in Kwala Lumpur can only supply 550,000 gallons per diem.

It will be apparent from the above that increased and improved water supply for the larger towns is necessary even with the present population. Exclusive of any calculations based on a possible increase in the population the following alterations are necessary :—

(1) Increased or extra impounding reservoirs. The increase need not necessarily be in the same situation as at a lower elevation the greater part of the town could be easily supplied.

(2) Increase storage in proximity to the town. The present site of the reservoir is ideal but for the town and railway a service reservoir at a lower elevation would suffice.

(3) Increase in the filter area. The present rate of filtration is too high and no increased rate could be tolerated. Additional filter beds are urgently required. In case the present inadequate water supply be reserved for the higher parts only of the town and a supplementary water supply is established at a lower level the additional filter beds should be in connection with the new supply. The rate should never exceed $1\frac{1}{2}$ gallons per square foot of filter bed per hour. Far worse water than that in the Gombak River, the Klang or other rivers if passed through *efficient* filter beds proves quite satisfactory in other countries. There is no reason why with such modifications as are found requisite impure waters such as these should not be efficiently treated by filtration.

The modifications required must be decided on by the results of future work but will probably include greater depth of sand, finer quality of sand for the surface of the bed and slower rate of filtration.

Observations and experiments elsewhere are valuable guides to the observations and experiments required here, but it cannot be too strongly insisted on that the *results* of such observations elsewhere cannot be taken as guides to practical working here. The local conditions are different and it is only by the results of local determinations that complicated systems can be adapted to meet the local circumstances.

The effect of the water supply on the occurrence of disease cannot be determined at present. The areas of the town where other waters are used are so extensive that the general rate of intestinal disease cannot be fairly attributed to town water.

The occurrence of Typhoid amongst Europeans who drink exclusively town water is possibly due to the contaminated water used for the fraudulent dilution of milk and cannot be fairly attributed to the town water.

The gaol is supplied only by town water but this is boiled before use so that the freedom of the occupants of that institution from intestinal disease cannot be attributed entirely to the purity of the water.

Analyses have shown that chemically the water is very pure and free from the chemical products of the decay of animal or vegetable matter. In this it differs from the Singapore waters which contain a considerable amount of Albumenoid Ammonia.

The absence of smell and taste in the Ampang and Klang waters is probably to be attributed to this purity and the slower rate at which organisms grow through the filter bed as compared with Singapore is perhaps due to the same cause.



Singapore:

KELLY & WALSH, LIMITED,
32, RAFFLES PLACE AND 194, ORCHARD ROAD.

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